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Licenciatura em Escultura, Licenciatura em Engenharia Civil

ENTRE O HOMEM E A MATÉRIA
(da intimidade da matéria por acção da
vida e do calor)

Dissertação para obtenção do Grau de Mestre em
Arte e Ciência do Vidro

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“todo o conhecimento da intimidade das coisas é imediatamente um poema”¹

Gaston Bachelard (1948)

¹ BACHELARD, Gaston, *A Terra e os Devaneios do Repouso, Ensaio sobre as imagens da intimidade*, 2003, Martins Fontes, São Paulo, Brasil (1948 ed. original).

SUMÁRIO

O que é a matéria? Como alcançar a sua intimidade? Esta investigação parte de um questionamento e procura desenvolver uma reflexão à luz de um duplo olhar indissociável e humano, artístico e científico.

Do ponto de vista pessoal/profissional, o processo de trabalho configurou-se como um contributo transversal e reflexivo que dá visibilidade à natureza constituinte da interacção sujeito-matéria (matéria do corpo, matéria do mundo) e que se revela numa alteridade de caminho subjacente ao próprio fazer artístico.

Neste contexto, as investigações científica e artística decorrem em paralelo. Do ponto de vista epistemológico e estético, a temática contextualiza-se no pensamento contemporâneo e integra-se na óptica de Gaston Bachelard (com destaque para as obras *O Materialismo Racional* e *A Poética do Espaço*).

Em Bachelard, a raiz de *ser-se humano* decorre da articulação entre a razão e a imaginação. Desta forma, partimos de uma dialéctica que possibilita o aprofundamento do conceito. Entre o olhar que normaliza, que procura, que discerne e o que é olhado e se deixa submergir pelo mundo, cria-se um movimento relacional e de abertura.

Do ponto de vista científico, desenvolvem-se duas linhas de investigação (duas formas de aproximação da intimidade da matéria): uma por acção da vida e a outra por acção do calor.

No decorrer das investigações, o aprofundamento do conceito possibilita uma articulação de sentido que coloca em causa o próprio fazer artístico. Entre o homem e a matéria, dá-se a inversão do sentido de habitar e é o acto poiético que torna visível esse indizível.

A série de trabalhos artísticos que acompanha a dissertação advém de duas exposições que foram desenvolvidas no contexto da investigação e apresentadas no Museu Nacional da Ciência e História Natural da Universidade de Lisboa.

Palavras-Chave: matéria, razão, imaginação, arte, ciência, *poiesis*

ABSTRACT

What is matter? How might we grasp its intimate nature? This investigation emerges from questioning the *nature of matter* and allows us to take a double perspective on the subject: between and within science and art.

From both personal and professional points of view, this work is an attempt to say something about the constituent relationship between man and matter (our own body's matter and the world's matter) which implies the experience of otherness and results in a continuous change of one's own "artistic doing".

Therefore, the scientific and artistic investigations run in parallel. The subject takes place in the context of contemporary thinking and it is developed from both epistemological and aesthetic points of view. This investigation is also related to Gaston Bachelard's work (with particular reference to *Rational Materialism* and *The Poetics of Space*).

According to the author, being a human is being able to articulate both reason and imagination. Therefore, man stands in a place between the *discerning vision* and *the one that is looked into or submerged by the world*.

From the scientific point of view, two investigations were undertaken (two different ways of approaching the concept of *matter*), one through life and the other one through heat.

This intrinsic dialectic allows us to approach the main subject and acquires expressiveness and form in the "artistic doing". Between man and matter, there is an inversion of the dwelling sense and it is the *poietic act that gives visibility to the unutterable*.

The theoretical research culminates in a series of artworks presented in two exhibitions which took place in the National Museum of Science and Natural History.

Keywords: matter, reason, imagination, art, science, *poiesis*

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INTRODUÇÃO

“A natureza não tem de se adaptar à nossa maneira de pensar. É a nós que cabe mudar a maneira de pensar para que ela se adapte à natureza.”²

Hubert Reeves (1981)

Do tema, problemática, variáveis, objectivo da investigação

A presente dissertação intitula-se «entre o homem e a matéria (da intimidade da matéria por acção da vida e do calor)». A temática do sujeito e da matéria inseriu-se em contexto académico de conclusão de mestrado e decorreu da necessidade de valorização pessoal e profissional por via do aprofundamento reflexivo artístico e científico. Num universo de estudo exploratório do tema, por um lado, recolheram-se elementos teórico-conceptuais. Por outro investigou-se a matéria do vidro e elaboraram-se relatórios científicos. Fruto de um cruzamento indissociável de saberes teórico-práticos, evidenciaram-se no corpo do trabalho duas exposições públicas. Tratou-se de um contributo pessoal/profissional para um processo de valorização de saberes no âmbito da construção e desconstrução reflexiva, formativa e relacional.

Qual a intimidade da matéria? Foi esta a questão de partida da nossa abordagem teórico-prática. O que é a matéria? Como alcançar a sua intimidade? Foram estes os problemas base que levaram à delimitação de duas variáveis de incidência no estudo: a acção da vida e a acção do calor sobre a matéria. No processo da investigação em curso, no âmbito do Mestrado em Arte e Ciência do Vidro, subjaz uma reflexão acerca da globalidade da matéria (a vida e a não vida), prosseguindo na pegada de Bachelard (ou bachelardiana). Na triangulação da investigação teórico-prática emergiu o acto poiético. A série de trabalhos artísticos que se apresentam são marcas da intimidade da matéria que, sendo não dizível, assumiu um rasto de visibilidade.

² REEVES, Hubert, *Um pouco mais de azul. A evolução cósmica*, Gradiva, Lisboa, 1984, p.161.

A questão de partida continua em aberto. Configuram-se, no entanto, como indicadores de caminho a prosseguir, o da reflexão, investigação e acção criativa do sujeito no âmbito da ciência e da arte.

Do enquadramento temático

Na última metade do século XIX e ao longo de todo o século XX, o mundo assistiu a uma profunda desconstrução do paradigma clássico. A matriz da racionalidade científica abriu-se e passou a tolerar dentro de si um discurso múltiplo ou plural, ao invés de um modelo universal. A ciência contemporânea “radica precisamente na substituição dessa tranquilidade por uma intranquilidade não acidental, indissociável da epistemologia não-cartesiana que preside à ciência contemporânea” (Freitas Branco: 1989, 212). No caso da física e da química, a impermanência torna-se a base de incidência dos mecanismos processuais, contrastando com os princípios clássicos de permanência e imutabilidade. É no seio da própria ciência que o *conceito de devir*³ se presencia “em palcos científicos tão díspares como sejam os da biologia ou da astrofísica, o da sociologia ou o da física.” (Freitas Branco: 1989, 215). Neste sentido, a ciência contemporânea passa a preocupar-se em captar o *automovimento* associado a todas as coisas, não como repetição de processos, mas como articulação de factores ou elementos contraditórios. A *definição*, no sentido clássico, perde o valor científico que lhe era atribuído pois o objecto da própria ciência passa a ser o *fenómeno em devir*. O conjunto de metamorfoses no seio da ciência implica também a noção de uma *verdade relativa e constituinte*.

Denote-se que a teoria da relatividade e a mecânica quântica não vieram destituir os princípios clássicos. O que se apreendeu foi que esses princípios “possuem uma validade relativa por serem aplicáveis com rigor apenas a determinada área experimental, e não à totalidade dos sectores da experiência.” (Freitas Branco: 1989, 215) É a partir deste ponto fundamental que se desenvolve a presente reflexão.

O conceito de *matéria* revela-se no interior de um universo múltiplo, indeterminado, nebuloso. *A matéria revela-se enquanto devir*. Trata-se de aumentar a imagem a partir de um campo matricial sempre em construção, sempre inacabado. A relação entre o homem e a matéria, a aproximação à intimidade do conceito constrói-se num movimento em extensão e não de implantação em torno de um único ponto de vista. O exercício desenvolve-se num

³ A ciência contemporânea «toma o devir como base do processo mental.» (Bento Jesus Caraça cit. por Freitas Branco: 1989, 215).

duplo sentido, entre o universo cosmológico e o infinitamente pequeno. Os limites perscrutam-se através das linhas de rasto, do *negativo* das acções.

Entre a razão e a imaginação, há um convívio com o real que parte da humanização do conceito. “Começamos a compreender que a terra é o lugar da vida e não do julgamento” (Tchernichvsky cit. por White: 2008, 23). Num movimento difícil de definir, o *acto poiético* abre espaço para o espírito de criação. *Inverte-se o sentido de habitar*.

1ª PARTE

do sujeito - entre a razão e a imaginação

“O ninho do homem, o mundo do homem, nunca acaba. E a imaginação ajuda a continuá-lo. O poeta não pode abandonar uma imagem tão grande, ou mais exactamente, tal imagem não pode abandonar o seu poeta.”⁴

Gaston Bachelard, 1957

Debruçamo-nos sobre as reflexões de Bachelard, das quais podemos isolar duas faculdades que movimentam a sua obra: a *razão* e a *imaginação*. A relação entre ambas ganha espaço na figura do *sujeito* (*o ser humano*) e da sua *abertura ao real*. “O significado da sua metafísica – que existe, motiva e orienta o seu trabalho – é imanente às obras que se convencionaram chamar de Epistemológicas e de Fenomenologia da Imaginação” (Simão: 2010, 17).

O *sujeito* de Bachelard caracteriza-se pelo *devir* e reconhece-se num universo “onde todas as formas são tocadas por uma fluidez essencial” (Simão: 2010, 23). A *razão* e a *imaginação* são também constituintes (constituem-se no acto de se fazer).

Na obra «A Poética do Espaço», o autor dedica o capítulo «A Casa. Do Porão ao Sótão. O Sentido da Cabana.» à condição de “ser-se humano «da racionalidade do telhado à irracionalidade da cave»” (Simão: 2010, 29). Ao percorrer as várias divisões da casa, o *sujeito* percorre as tensões que o habitam. A articulação entre a razão e um outro que não ela será feita por uma faculdade criadora e dialéctica, a *imaginação*. Segundo Bachelard (1989:36) “A verticalidade é proporcionada pela polaridade do porão e do sótão. As marcas desta polaridade são tão profundas que, de certo modo, abrem dois eixos muito diferentes para uma fenomenologia da imaginação.” A morfologia estrutural do telhado revela imediatamente a sua função: o telhado protege o homem da chuva e do sol. Os geógrafos descrevem o declive do telhado como uma das características mais seguras do clima de uma região. A maior inclinação facilita o escoamento das águas e da neve e revela um lugar onde o clima rigoroso é manifesto. Os telhados com inclinações suaves (quase horizontais) são

⁴ BACHELARD, Gaston, *A Poética do Espaço*, Martins Fontes, São Paulo, Brasil, 1989, p.116.

característicos das terras quentes, onde a chuva é escassa e o vento brando. Nas açoteias secam-se os frutos, aproveita-se a intensidade do sol para preservar os alimentos. Os telhados revelam as necessidades concretas das gentes que os habitam e no sótão “vê-se a nu, com prazer, o forte arcabouço do vigamento. Participa-se da sólida geometria do carpinteiro” (Bachelard: 1989, 36).

“No porão, também encontraremos utilidades, sem dúvida (...) Mas ele é a princípio o ser obscuro da casa, o ser que participa das potências subterrâneas. Sonhando com ele, concordamos com a irracionalidade das profundezas” (Bachelard: 1989, 37). E é nas profundezas da casa que o ser humano escava a intimidade da terra. “Quanto ao porão, o habitante apaixonado cava-o cada vez mais, tornando activa a sua profundidade. O facto não basta, o devaneio trabalha. Com relação à terra cavada, os sonhos não têm limite” (Bachelard: 1989, 37).

A casa é imaginada como um ser vertical e concentrado: a verticalidade é gerada pela polaridade da cave e do sótão e a concentração revela a primitividade do refúgio, o centro de simplicidade da casa.

O ser humano habita esta polaridade que é dupla e vertical. Mesmo que os medos habitem o sótão, a racionalização será sempre mais rápida e clara pois a experiência do dia poderá dissipar as trevas da noite. Na cave, as trevas desenham-se de noite e de dia. Diz-nos Bachelard (1989:38) “mesmo com uma vela na mão, o homem vê as sombras dançarem na muralha negra do porão”, e mesmo na civilização contemporânea (que coloca a luz eléctrica em toda a parte), segundo o autor, “o inconsciente não se civiliza. Ele apanha a vela para descer ao porão.” É através do além-cave que o ser humano perscruta o mundo. As paredes da cave estão enterradas na terra. São paredes que contêm “toda a terra atrás de si. E com isso o drama aumenta e o medo exagera” (Bachelard: 1989, 38).

Na obra «Metáforas do Saber e da Luz», Frei Hermógenes Harada (2009) descreve uma pequena fábula que parte também das relações entre a casa e a terra para questionar a abertura do ser-humano ao real e a limitação do nosso saber objectivo.

O autor centra-se na metáfora do questionamento do sapo e do poço: “«A Terra é tão grande como o meu poço?» A Terra não cabe no poço pois o poço está contido na Terra” (Harada: 2009, 122). O sapo que vive dentro do poço procura compreender a terra a partir do ponto de vista do poço e a certa altura da sua reflexão dirá “«Maior, menor, tão grande são termos comparativos. A comparação só tem sentido dentro de uma medida a partir da qual posso

comparar. Essa medida no entanto só diz respeito ao meu mundo. Pois ela nasce, vive e opera a partir do meu mundo»” (Harada: 2009, 122).

A suspeição de que a terra seja muito maior do que a sua casa leva-o a uma intuição inaudível: “«*Donde* vem a suspeita do além poço? Como posso falar do nada, do não-tudo, do não-Ser, se o ‘outro’ não está de alguma forma já presente em mim? Se estou realmente preso irremediavelmente no meu poço, nem sequer poderia suspeitar do não-poço!»” (Harada: 2009, 122). Este evento, no entanto, ao invés de facilitar o seu saber, revela-lhe precisamente o contrário. É a *transformação do próprio saber (a intuição que desvela a presença do outro)* que se transforma na questão fundamental da sua vida: “«como saber o meu não saber?»” (Harada: 2009, 123).

Na terra que cerca as paredes do poço, vive uma minhoca. Tal como refere o autor, a sua casa é a terra. “Como o peixe vive na água, a minhoca vive, in-siste no húmus, no suco da Terra. Por assim dizer, a minhoca é a carni-ficação da Terra, o lugar onde a Terra se abre e se re-colhe como sensibilidade, ressonância e concentração” (Harada: 2009, 123). Certo dia, a minhoca ouviu o monólogo do sapo e respondeu para os seus botões: “Creio que não há resposta para essa pergunta. Pois como pode o envolvido perguntar pelo envolvente *dessa maneira* como o sapo pergunta? O sapo mora no buraco da Terra. Quem sustenta, cerca o espaço vazio do buraco é a Terra. Todas vibrações da Terra impregnam e pulsam também no espaço vazio da Terra. (...) O espaço da Terra, onde habita todo um mundo de espaços variegados e poliformes na sua pujança, intensidade, impregnância, liberdade, resistência e abertura, só é possível ser apreendido se me torno permeável, ressonante à presença envolvente da vibração-Terra. O sapo, no entanto, só tem antenas para o espaço do vácuo mensurável em trechos objectivos de maior ou menor e tenta a partir dessa medida deficiente para abranger a grandeza Terra. E nem sequer se dá conta de que a própria abertura do poço tem o seu espaço de jogo a partir de dentro da Terra que ele quer medir.»” (Harada: 2009, 123).

O ser que reverbera a própria Terra (o espaço envolvente) questiona o ser que vive dentro do poço (no espaço envolvido). No entanto, esta fábula ensina-nos que o espaço do poço não se circunscreve pelo ‘outro’. O negativo da Terra é sustentado pela própria Terra. Todas as vibrações, intensidades, fricções e aberturas pulsam também no poço. O espaço da Terra, porém, só pode ser apreendido pelo ser, se o mesmo se tornar ressonante à sua presença. O negativo da função de habitar é então testemunho de uma dialéctica que se desconstrói. O espaço habitado começa a abrir-se quebrando os limites do espaço geométrico.

Retomando a obra *A Poética do Espaço*, o autor revela vários exemplos que cumprem redescobrir a raiz axial da função de habitar e que denunciam múltiplas possibilidades de articulação.

No reino da imaginação, o Inverno aumenta o valor da casa habitada. “No mundo fora da casa, a neve apaga os passos, embaralha os caminhos, abafa os ruídos, mascara as cores. Sente-se em acção uma negação cósmica pela brancura universal. O sonhador da casa sabe tudo isso, sente tudo isso, e pela diminuição do ser do mundo exterior sente um aumento de intensidade de todos os valores de intimidade” (Bachelard 1989, 57). A dialéctica casa-universo dinamiza-se apresentando-se para o poeta Rilke como a “inversão da função de habitar (...) Rilke, abrigado na casa, gostaria de estar *lá fora*, não por necessidade de desfrutar o vento e a chuva, mas para uma busca de devaneio” (Rilke cit. por Bachelard: 1989, 59).

Por vezes, o espaço revela-se uma extensão em potência. Para o habitarmos, é preciso uma maior elasticidade de pensamento, como a casa de Georges Spyridaki (1989) que respira e transcende a geometria cartesiana. A minha casa “é diáfana, mas não de vidro. Teria antes a constituição do vapor. As suas paredes condensam-se e expandem-se segundo o meu desejo. Por vezes, aperto-as em torno de mim, como uma armadura de isolamento. Mas, às vezes, deixo as paredes da minha casa se expandirem no espaço que lhes é próprio, que é a extensibilidade infinita” (Spiridaky cit. por Bachelard: 1989, 66).

A casa torna-se reveladora do estado da alma e é através da perscrutação das subtilezas que nos aproximamos dos valores da casa-habitada. A psicóloga Françoise Minkowska⁵ analisou muitos desenhos de casas feitos por crianças. Estes desenhos abrem-se à espontaneidade e a criança revela os seus sonhos mais íntimos. “Se a criança é infeliz, a casa traz a marca das angústias do desenhista (...) coisas imóveis, casas imobilizadas em sua rigidez (...) árvores rectas” (Bachelard: 1989, 85). No entanto, sabemos que a casa viva e habitada traz consigo uma fluidez inerente. A casa é marcada pelos *signos*⁶ da nossa vivência, da nossa intimidade. O autor dá-nos o exemplo da maçaneta. É a sua “função que predomina sobre qualquer preocupação com o tamanho. Ela expressa uma função de abertura (...) Só um espírito lógico pode objectar que ela serve tanto para fechar como para abrir. No reino dos valores, a chave fecha mais do que abre. A maçaneta abre mais do que

⁵ Minkowski, “Recueil d'articles 1923-1965, Psychopathologie - Expression et langage - Phenomenologie”, Cahiers du Groupe Françoise Minkowska, Paris, 1965.

⁶ Denota-se que a construção do signo revela a relação permanente entre o significante e o significado (ou referente).

fecha. E o gesto que fecha é sempre mais nítido, mais forte, mais rápido que o gesto que abre” (Bachelard: 1989, 85).

Partimos da relação casa-universo no sentido da criação de permeabilidades possíveis e entramos depois nos gestos de intimidade que caracterizam a raiz mais profunda da função de habitar. Bachelard (1989) dedica o capítulo *O ninho* à associação de imagens que relacionam os seres e os seus refúgios. A casa-ninho é o *signo* da volta. O pássaro regressa ao ninho e entre o cruzar das estações, a casa envelhece e é reconstruída sucessivamente. Os “regressos humanos acontecem de acordo com o grande ritmo da vida humana, ritmo que atravessa os anos, que luta pelo sonho contra todas as ausências. Nas imagens aproximadas do ninho e da casa repercute um componente íntimo de fidelidade” (Bachelard: 1989, 111).

Ao percorrer os gestos de intimidade, Bachelard (1989) apresenta-nos o *ninho Michelet*⁷, onde a forma se constrói a partir do interior. O decalque é feito de dentro para fora e a ferramenta do pássaro é próprio corpo, “é o seu peito com o qual ele aperta e comprime os materiais até torná-los absolutamente dóceis, até misturá-los, sujeitá-los à obra geral (...) É virando-se constantemente e recalcando as paredes de todos os lados, que ele consegue formar esse círculo. A fêmea, um torno vivo, escava a sua casa” (Bachelard: 1989, 113).

Se aprofundarmos racionalmente o nosso saber sobre o *ninho* compreendemos rapidamente que esta é uma construção precária, facilmente exposta às intempéries, e no entanto, “desencadeia em nós um devaneio de segurança” (Bachelard: 1989, 115). *A resposta a esse paradoxo é simples*, diz o autor, “revivemos, numa espécie de ingenuidade, o instinto do pássaro” (Bachelard: 1989, 115).

Na obra *Entre o Corpo e a Paisagem*, Armando Rabaça (2011) apresenta *três formas de habitar* que nos revelam os instintos primordiais de refúgio e celebram também a razão e a capacidade técnica do homem. A primeira habitação, “ \sqrt{geu} , deriva no termo grego *gýpé*, que significa viver num buraco.” (Rabaça: 2011, 17) O termo *gýpé* remete-nos ainda para um significado mais profundo, associado ao próprio corpo, “as formas curvas, côncavas e convexas dos órgãos anatómicos, reforçando a identidade da caverna como útero materno.” (Rabaça: 2011, 25) A segunda forma de habitar, $\sqrt{*keu}$, deriva em “palavras que se referem a habitáculos escavados, construções de cariz provisório” (Rabaça 2011, 17) que comportam a acção do corpo que encerra um espaço pré-existente, como por exemplo o

⁷ Jules Michelet, filósofo e historiador, escreve o livro *L’oiseau* (primeira publicação em Março de 1956) do qual Bachelard retira os exemplos relacionados com a construção do ninho.

acto de tapar um buraco com uma cobertura de peles ou ramagens. A sedentarização dos povos abre lugar à raiz \sqrt{dem} , da qual têm origem as palavras “grega *domos* e latina *dómus*, casa. Subjacente a esta raiz está a ideia de construção (...) da alteração do mundo natural” (Rabaça: 2011, 18). A raiz \sqrt{dem} consubstancia o domínio técnico da matéria pelo homem.

O espaço habitado, a sua natureza, refere o autor, “remete sistematicamente para a arquitectura como expressão do entendimento do mundo, como definição da identidade cultural e religiosa (...) muito para além da função de abrigo, habitar implica a conquista do espaço e a sua transformação em lugar, operada, no primeiro momento, através do sagrado” (Rabaça: 2011, 18).

As duas primeiras formas de habitar (\sqrt{geu} e $\sqrt{*keu}$), características dos povos nómadas, comportam a escolha de um lugar a partir do instinto elementar de protecção, de defesa, de envolvimento. As duas raízes associam-se à “forma redonda, a mais simples e elementar, a que mais directamente se identifica com o sentimento de protecção, refúgio, acolhimento, abrigo, com o estado original embrionário” (Rabaça: 2011, 29). A relação destes povos com a paisagem é dinâmica e traduz-se numa profunda relação com os ciclos da natureza.

A terceira forma de habitar (\sqrt{dem}) comporta a razão e a capacidade técnica humana como estruturas fundamentais para a permanência num lugar. A casa transforma-se num espaço que se circunscreve na paisagem. Constroem-se muros, delimitam-se fronteiras e o homem enfrenta, *domestica* os territórios hostis. A paisagem construída pelo homem passa a ser constituída por diversos pontos fixos que revelam fronteiras e delimitações, mas a experiência do espaço, a sua apreensão, depende profundamente do movimento. A articulação dos eixos horizontal e vertical densifica a relação do homem com o mundo: “o horizonte enquanto linha que delimita o espaço do homem, que diferencia e separa o céu da terra ou do mar” (Rabaça: 2011, 41) e a própria terra, os limites da terra, os limites exteriores do lugar.

Neste contexto, João Barrento (2006) afirma que o artista judeu Dani Karavan recebia os visitantes no pavilhão israelita da Bienal de Veneza de 1976 com a inscrição «As oliveiras deviam ser as nossas fronteiras.», sublinhando que o princípio orientador da obra do artista assenta num “encontro sem violentar a paisagem” (Barrento: 2006, 192). O nomadismo permanece na contemporaneidade, *mas este é um nomadismo diferente*, que simboliza perseguição e exílio. Hoje é ainda o tempo das “deslocações forçadas, e não daquela «involuntária compulsão da errância» que nos está no genoma de animais sazonais” (Barrento: 2006, 193). Mas há ainda o *nomadismo do pensamento*. O autor ensina-nos,

“convencional é adjectivo que não convém a nenhum destes dois espíritos, artista e filósofo acentrados e errantes. O nomadismo da ideia que os anima fá-los percorrer todos os espaços da imaginação e do pensamento. Sem fronteiras e sempre na fronteira” (Barrento: 2006, 197).

Por isso, o sujeito (*o ser que vive dentro do poço*) reparte-se entre as fendas que se abrem nas próprias paredes do poço e o céu que se projecta para além da visão. A reverberação da Terra torna-se reflexo do céu. As fendas abrem-se em todos os sentidos e a existência velada do ‘outro’ já não se trata de uma intuição inaudível mas de um sentido de convergência que gera visibilidade. Trata-se da aproximação do mundo através da matéria (matéria do corpo, matéria do mundo). Trata-se de ver, de apreender a partir da espessura, das distorções, dos reflexos. Trata-se de prestar atenção a partir de múltiplas articulações e de tomar consciência da ressonância entre o próprio ser e o mundo. Talvez por isso, o caminho não seja apenas operar no Universo, mas deixar-se confluir pelo mesmo.

Retomamos a *casa-homem* de Bachelard (casa-pássaro, casa vertical, casa-universo, casa íntima) que procura encontrar a raiz de *ser-se humano*; em suma, encontrar na *razão* e na *força imaginante*⁸ os sentidos agregadores do *ser no mundo*.

⁸ Na óptica Bachelardiana, a imaginação “não é escapar ao mundo, mas sim o trazer a si o mundo e o fazer-se ao mundo.” (Veiga Simão: 2010, 65).

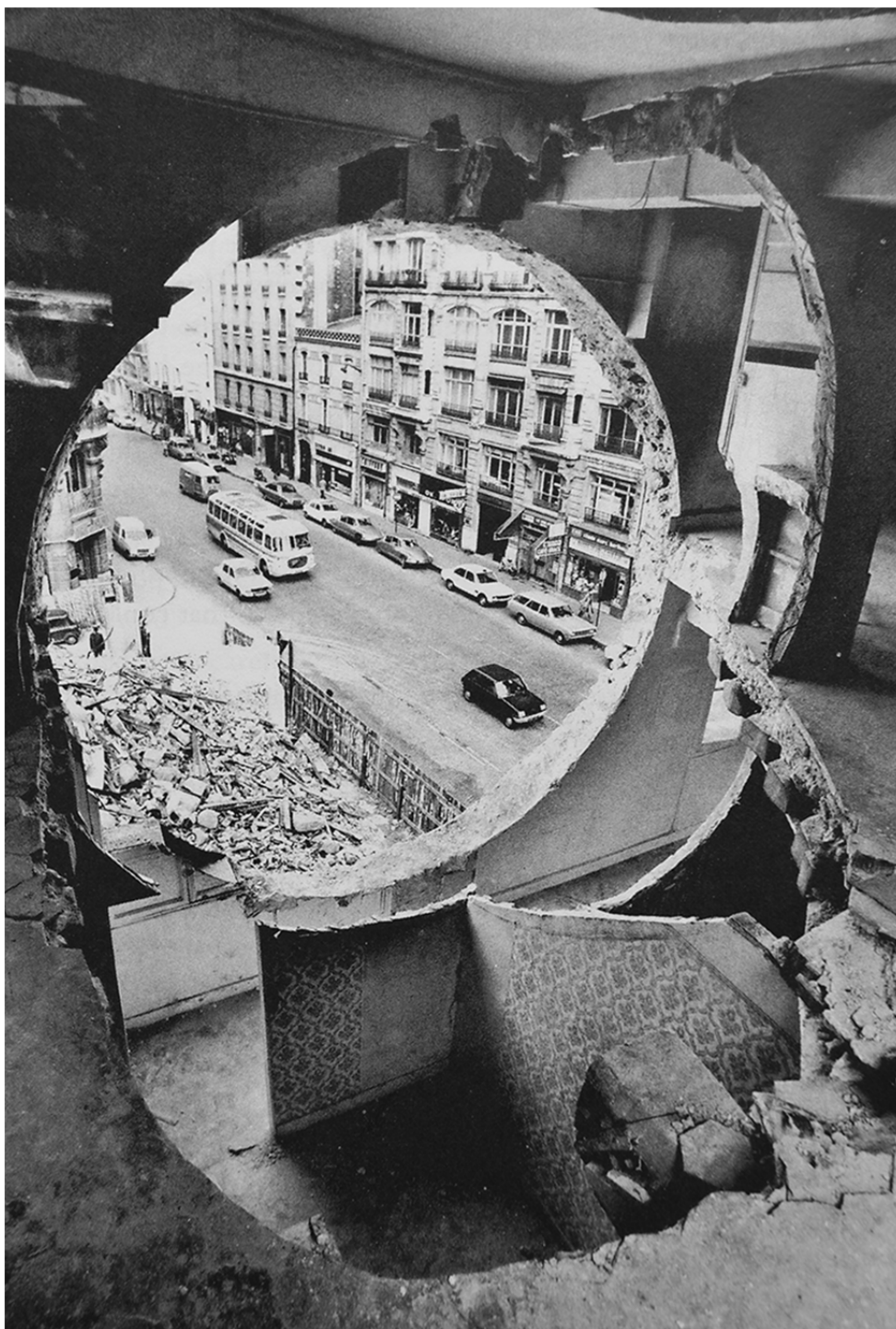


fig. 1 – *Conical Intersect*, Gordon Matta-Clark, 1975

© Estate of Gordon Matta-Clark (ARS), New York

da matéria – o racionalismo da matéria

“Passamos da escuridão à luz e da luz à escuridão. De cada vez, ficamos apavorados, com medo de abandonar o mundo que já conhecemos, de acabar, de chegar ao fim. Mas tudo é apenas uma passagem para outro universo, para um novo estado, um novo mundo...”⁹

Rui Chafes, 2012

Dedicamo-nos neste capítulo à articulação de novas formas de aproximação da *matéria* (novos modos de conhecer) decorrentes de uma mudança de paradigma que nasce no seio da ciência contemporânea. “Espaço, tempo, determinismo (...) tornaram-se de um momento para o outro, problemas complexos (...) donde resulta um desmembramento quase absoluto não só da imagem física do mundo, como também, logicamente, dos elementos de análise científicos e epistemológicos” (Blanché¹⁰: 1983, 11). Os *à priori* espaço e tempo (princípios de permanência e causalidade característicos do pensamento clássico) dão lugar à desconstrução do conceito a partir da própria razão. Assim, à medida que o sujeito utiliza várias escalas (entre o infinitamente pequeno e o infinitamente grande), há a possibilidade de criação de múltiplas articulações, particularmente no que se refere à relação entre o homem e a matéria.

Iniciamos então o nosso percurso no sentido da redução da escala. Nos seus estudos acerca das instâncias da matéria, Bachelard (1990) analisa as antigas concepções que se constituem a partir dos quatro elementos (água, terra, fogo, ar) para dar lugar às propriedades intermateriais apenas acessíveis através de instrumentos e da respectiva racionalização do conceito. A matéria existe na sua pluralidade: entre a realidade quotidiana e o universo infinitamente pequeno (do átomo e do núcleo atómico) há uma diferença fundamental. O acesso ao núcleo atómico apenas é possível através da ciência.

Trata-se de “compreender e caracterizar o materialismo instruído” (Veiga Simão: 2010, 32). Coloca-se em causa a questão da acessibilidade aos diferentes níveis da realidade. Assim, se na física clássica é possível distinguir a energia e a matéria, na física atómica os termos

⁹ CHAFES, Rui, *Entre o céu e a terra*, Documenta, Lisboa, 2012, p.40;

¹⁰ Filósofo (1898-1975), professor da Universidade de Toulouse. Desenvolve um trabalho extenso de investigação na área da Epistemologia e Lógica.

difundem-se. Um átomo muda de forma porque recebe e liberta energia. Neste processo, existe uma reconversão de energia em matéria, um devir/ser ou uma evolução no sentido da irradiação ao corpúsculo.

As transacções da matéria assumem um ponto fundamental no pensamento científico contemporâneo: *da matéria devém a forma*¹¹.

“Como não pôr, perante tais fenómenos, a prioridade da matéria sobre a forma? Então seria a matéria que se daria uma forma, a matéria que manifestaria directamente as suas potências de deformação. A própria matéria é que sai das prisões da forma. A forma não é talhada de fora, imposta de fora” (Bachelard: 1990, 26). São as transacções da matéria, a “acção material de umas matérias sobre as outras” (Bachelard: 1990, 18) que definem a *própria matéria enquanto devir*.

A acção do tempo sobre a matéria remete-nos também para uma dimensão plural. O objecto enquanto sinal da matéria, ou a permanência da exterioridade e da forma são condições que devem ser aprofundadas. “Quanto muito, forma e objecto não são senão um instante da matéria. O tempo da matéria é mais vasto, mais fortemente condicionado que o tempo dos objectos. As condições temporais das transacções materiais, das misturas das substâncias não estão mais profundamente inscritas na matéria que as simples transformações exterioristas” (Bachelard: 1990, 26).

Quando aproximamos os dedos uns dos outros, quando tocamos em algo, diz Eugene Chudnovsky¹² em entrevista com Punset (2009), “os electrões da minha mão são repelidos pelos electrões do outro corpo, e é por essa razão que a minha mão não consegue, na realidade, atravessar o teu corpo” (Chudnovsky cit. por Punset: 2009, 54). Punset acrescenta, “Se não fosse assim, seríamos engolidos pelo solo (...) o que estamos a dizer é que *andamos sobre uma nuvem de electrões*. Não estamos colados ao solo, pois segundo o que tu dizes, se não houvesse electrões entre nós, atravessá-lo íamos” (Punset: 2009, 54).

A matéria acrescenta-se no desconhecido. Aos átomos acrescentam-se os núcleos, os quarks, as supercordas, baixando de escala. *Aos átomos acrescenta-se a incompletude do saber*.

¹¹ É a ciência química, a física nuclear e *a natureza das estrelas* que caracterizam a criação de novas instâncias materiais. O jogo de transformação das substâncias e de formação de moléculas é desenvolvido pelos químicos enquanto a formação dos elementos é praticada pelos físicos nucleares.

¹² Físico e professor na Universidade de Nova Iorque, onde dedica a sua investigação científica aos efeitos quânticos macroscópicos em supercondutores e ímanes .

“No passado, digamos há vinte anos, dizia-se que tudo era formado por partículas pontuais, uma espécie de partículas muito pequenas, poder-se-ia dizer esféricas. Agora, porém, sabemos que há objectos que não são formados por átomos e que podem ser objectos muito extensos, como as cordas¹³” (Chudnovsky cit. por Punset: 2009, 54). *E ainda outros tipos de matéria*: o “mistério da astrofísica, a chamada *matéria escura* (...) as experiências demonstram que a única maneira de explicar as forças de gravitação e a evolução do universo – a atracção entre objectos diferentes – é assumindo que a massa do universo é dez vezes maior do que aquilo que observamos” (Chudnovsky cit. por Punset: 2009, 53).

Tal significa que há substâncias às quais não conseguimos ainda aceder, mas que existem no Universo e que o constituem profundamente. A presença da matéria escura é inferida pelo efeito das forças que afastam os objectos astronómicos; no entanto, esta matéria não interage com as ondas de luz ou da matéria que conhecemos. *A matéria escura habita-nos através dos seus efeitos, através do registo da sua acção.*¹⁴

A energia escura também é inferida através do registo da sua acção. Até aos finais do século XX, pensava-se que a expansão do universo estava a abrandar sucessivamente devido aos efeitos da força da gravidade (*a força que aproxima os corpos*). No entanto, em 1998, observações oriundas do telescópio Hubble mostraram que supernovas muito distantes estavam a expandir mais devagar do que o universo que conhecemos hoje. (*Não esquecer que olhar as estrelas é aceder ao passado.*¹⁵) Tal levou à seguinte inferência: a expansão do universo não está a desacelerar, mas sim a acelerar sucessivamente. *Há uma força misteriosa, invisível aos nossos olhos, que acelera a expansão do universo.* Não a vemos mas inferimos a sua presença através da observação dos seus efeitos.

¹³ Nota: A teoria das cordas não está comprovada experimentalmente. Actualmente, “não há qualquer indicação experimental da existência das cordas na natureza” (Laughlin: 2008, 304)

¹⁴ “Dark matter is not visible, although its presence and distribution is found indirectly through its effects. Dark matter can act like a magnifying glass, bending and distorting light from galaxies and clusters behind it. Astronomers can use this effect called gravitational lensing to infer the presence of dark matter in massive galaxy clusters.” (Peroto e Villard: 2012)

¹⁵ A título de exemplo, a luz do Sol demora 8 minutos a chegar à Terra. (Rumburg: 2012) A observação de supernovas distantes permite-nos estudar os princípios do universo.

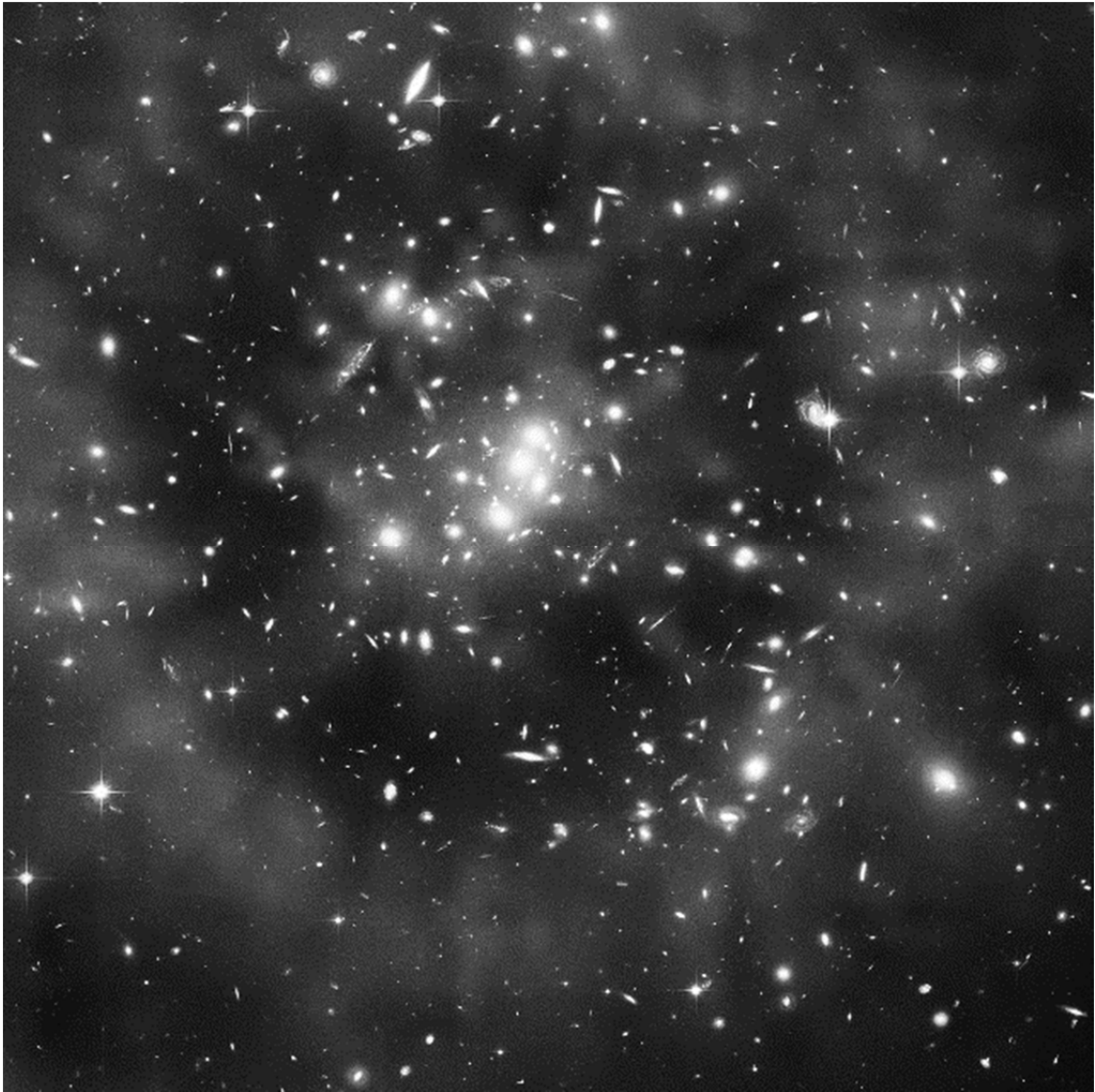


fig. 2 – *dark matter ring in galaxy cluster CL0024+17*, Hubble Space Telescope 2008,
© NASA, ESA, M. J. Jee e H. Ford et.al. (Johns Hopkins Univ.)

No livro «O espírito nómada», Kenneth White (2008:260) fala sobre a possibilidade de estabelecimento de um “novo sistema de coordenadas seguindo as «linhas de rasto».” Segundo o autor, “trata-se de «um modo de avançar, de caminhar» (...) da «velocidade adquirida de uma embarcação na qual já não funciona o propulsor» (...) dos «traços do animal». Palavra muito rica, como se vê, que fala de marcha, de mar e de animal.” *As linhas de rasto abrem espaço para a criação de novas possibilidades de articulação.*

Neste contexto, Gonçalo M. Tavares (2013:112) questiona-se “De que ângulo vês o mundo? De que ângulo vês o outro? (...) Que gestos são estes, então, que interferem na lucidez individual e interna? Coloquemos uma hipótese: são os pensamentos, e os pensamentos são movimentos que interferem na interpretação do mundo e dos acontecimentos. Mudam aquilo que não se vê.”

Diferentes observações dão lugar a múltiplas formas de interpretar. O olhar do cientista fixa-se no sentido do discernimento do visível; neste processo, “*decide-se*, por determinados elementos e determinadas combinações (e não por outros ou outras), e daí resulta uma visão geral, uma teoria que liga racionalmente os diferentes elementos” (Tavares: 2013, 65). Trata-se por isso de uma analogia ou de uma articulação que nos permite associar os elementos sem entrar na tautologia. O pensamento é um devir que se multiplica continuamente através de novas ligações; “tudo o que podemos fazer é mudar o estilo do pensamento (...) e persuadir as pessoas a mudar os seus estilos de pensamento” (Wittgenstein: 1991, 58). Gonçalo M. Tavares (2013:67) acrescenta que um “grupo de investigadores decide, quase por votação implícita, (...) qual a analogia em que confiamos. (...) Quando se discute se a verdade é verdade ou falsidade, discute-se, no fundo – contesta-se – as analogias privilegiadas, as ligações escolhidas.” *Trata-se da intuição de que a verdade é constituinte e múltipla.*

A complexidade das coisas centra-se nas diferentes possibilidades de articulação entre o homem e a natureza. “Somos demasiado grandes para ver o minúsculo e demasiado pequenos para ver as galáxias (...) Encontramo-nos entre a cosmologia, o estudo das coisas grandes, e a física das partículas, o estudo das coisas mais pequenas do mundo” (Glashow¹⁶ cit. por Punset: 2009, 59). Mais uma vez, refere Bachelard (1989:185), “estamos presos nos embaraços da dialéctica do profundo e do grande; do infinitamente reduzido que aprofunda ou do grande que se estende sem limite.”

¹⁶ Sheldon Lee Glashow, físico e investigador. Recebeu o Prémio Nobel da Física em 1979, em conjunto com Abdus Salam e Steven Weinberg, pelo contributo para uma teoria de unificação das interacções débil e electromagnética entre partículas elementares.

Tabela 1 - Quadro de equivalência de unidades¹⁷

unidades	equivalência em metros	exemplos
	10^{-18} m	diâmetro do electrão / quark
femtómetro (fm)	10^{-15} m	raio do protão – 1 fm
picómetro (pm)	10^{-12} m	50-600 pm, diâmetros atómicos
nanómetro (nm)	10^{-9} m	0,1 nm, diâmetro do átomo de hidrogénio
micrómetro (μ m)	10^{-6} m	0,1 μ m, raio do retrovírus HIV
milímetro (mm)	10^{-3} m	9 mm, embrião de 5 semanas
metro (m)	1 m	1,7 m, altura média do ser humano
quilómetro (km)	10^3 m	8,846 km, altura do Evereste
	10^6 m	6371 km, raio da terra
	10^9 m	$0,7 \times 10^6$ km, raio do sol
segundo-luz ¹⁸ (s/l)	300 000 000 m	499 s/l, órbita terrestre
hora-luz (h/l)	$1,08 \times 10^{12}$ m	10 h/l, raio do sistema solar
ano-luz (a/l)	$9,46 \times 10^{15}$ m	10^{15} a/l, diâmetro da Via Láctea
parsec ¹⁹ (pc)	$3,085 \times 10^{16}$ m	$3-7 \times 10^9$ pc, raio do universo visível

Wittgenstein (1992:14) coloca a questão: “Seria correcto dizer que ‘é difícil dizer o que é a verdadeira exactidão, visto que só conhecemos aproximações grosseiras’?”

Na macrofísica, associamos a resistência dos materiais a uma «mecânica do mole». Os corpos estudados nesta ordem de grandeza “deixam de se considerar perfeitamente rígidos (...) o cálculo das deformações dos corpos sob acção das forças actuantes é um dos principais objectivos da resistência dos materiais” (Nash: 2001, 1). O material dúctil deforma aos nossos olhos, ensina-nos a compreender a deformação no sentido da fractura. O material frágil quebra sem pré-aviso. A aproximação da física Newtoniana funciona para a construção de um abrigo, de uma ponte, de uma casa. *Na escala dos nossos olhos, tudo permanece sereno*. No entanto, a ductilidade e a fragilidade decorrem da microfísica. “A «mecânica do mole» permanece na perspectiva da macrofísica” (Bachelard: 1990, 23) mas não se concebe pelo princípio de Heisenberg. As grandezas que definem o domínio atómico

¹⁷ Fonte da tabela: (Punset:2009, 60).

¹⁸ O segundo-luz (s/l) consiste na distância percorrida pela luz em 1 segundo, no vácuo.

¹⁹ O parsec (pc) consiste numa unidade astronómica de distância cuja paralaxe anual média equivale a 1 segundo de arco. A paralaxe consiste na diferença da posição aparente de um objecto observado em locais distintos. O segundo de arco (1") consiste numa medida angular, da qual podemos fazer a seguinte relação: o círculo tem 360°, 1° corresponde a 60' (60 minutos de arco) e 1' corresponde a 60", logo, 1" corresponde a $1/(60 \times 60) = (1/3600)^\circ$.

entram na escala do picómetro e do femtómetro, onde as medidas de deslocamento atómico apenas se fazem através de modelos quantitativos, parâmetros estatísticos de aproximação.

No sentido da cosmologia, o modelo padrão dominante consiste na teoria da relatividade geral de Albert Einstein. Este modelo concebe uma relação entre o espaço-tempo-matéria como sendo essencialmente simétrica: a presença da matéria determina a curvatura espaço-tempo e esta determina o movimento da matéria. Quanto maior for a massa do corpo celeste, maior será a deformação do espaço-tempo na vizinhança do astro; assim, devido à curvatura do espaço-tempo, os corpos celestes com menor massa, giram à sua volta como se fossem atraídos pelo corpo com maior massa. Neste contexto, Einstein postulou que nenhuma experiência permite distinguir se um corpo está sujeito a uma aceleração \vec{a} , ou a um campo gravítico \vec{g} ²⁰ (uma das observações que leva à confirmação desta teoria consiste na curvatura da luz num campo gravitacional²¹). A teoria da relatividade restrita demonstra a não simultaneidade de eventos, dependendo do observador e do respectivo referencial de inércia e é generalizada pela teoria da relatividade geral para referenciais acelerados²².

A possibilidade de dilatação do tempo²³ e de contracção do espaço²⁴ são inerentes a este postulado²⁵. A teoria da relatividade ensina-nos que não existe um observador absoluto, que

²⁰ A título de exemplo, se um astronauta lançar um objecto no interior de uma nave espacial, este aproxima-se do chão, como se actuasse uma força gravítica. No entanto, não é o corpo que cai mas sim, o chão da nave que se aproxima do corpo ao se deslocar para cima com uma determinada aceleração \vec{a} .

²¹ Retomando o exemplo anterior, no interior de uma nave espacial com uma determinada aceleração \vec{a} , um astronauta observa um raio luminoso a entrar pela janela. Com o aumento da velocidade da nave, a trajectória do raio luminoso traduz-se numa parábola, pois a distância percorrida pela nave em cada intervalo de tempo, é cada vez maior.

²² O princípio da relatividade de Einstein diz-nos também que a velocidade de propagação da matéria será sempre inferior à da luz. Os átomos e as moléculas que constituem a matéria interligam-se através de campos electromagnéticos, os mesmos campos que caracterizam a natureza da luz. *Quebrar as barreiras da velocidade da luz, significa quebrar as próprias barreiras que caracterizam a matéria visível.*

²³ Imaginemos agora uma nave espacial que se desloca a uma velocidade \vec{v} em relação a um referencial de inércia. No interior da nave, é emitido um sinal luminoso que se propaga na direcção perpendicular ao movimento da própria nave e que é reflectido num espelho. Um observador está dentro da nave e mede o intervalo de tempo entre a emissão e a recepção do sinal luminoso. Num referencial de inércia exterior à própria nave (como por exemplo, a Terra), a distância percorrida pela luz será maior pois é necessário ter também em conta a distância percorrida pela nave. Como a luz se propaga a uma velocidade constante, um observador localizado no referencial Terra (um referencial exterior ao do acontecimento) mede um intervalo de tempo maior do que o tempo próprio. *Há uma dilatação do tempo medida a partir do referencial exterior ao acontecimento.*

²⁴ Imaginemos um observador parado no meio de um comboio que se desloca a uma certa velocidade \vec{v} entre os pontos A e B. Imaginemos também outro observador parado na Terra no ponto médio entre A e B. No instante em que o centro geométrico do comboio passa pelo ponto médio entre A e B são emitidos dois flashes de luz. Nesse instante, o observador que está parado em terra vê simultaneamente os dois flashes (pois para ele, percorrem distâncias iguais); o observador que está no comboio vê primeiro o flash emitido em B, pois, ao deslocar-se com o comboio, a distância percorrida por este sinal é menor do que a percorrida pelo flash emitido em A. Para o observador do comboio, os eventos não foram simultâneos. *Há uma contracção do comprimento na direcção do movimento.*

cada observação depende da posição do observador e do observado e que a objectividade absoluta não é racionalmente alcançável.

A teoria da relatividade assume-se também como essencialmente continuísta, ou seja, a matéria define-se de forma contínua (não discreta) entre os diferentes pontos no espaço. Refere Einstein (1916: 83) “I can get from any one point (...) to any other point by passing continuously from one point to a “neighbouring” one, and repeating this process a (large) number of times, or, in other words, by going from point to point without executing “jumps.” (...) We express this property of the surface by describing the latter as continuum.”

No sentido do aprofundamento da matéria, quebra-se novamente a rigidez edificada. O espaço e o tempo dão lugar ao múltiplo. “Teoria essencialmente continuísta, a relatividade aparece inesperadamente, no momento em que a própria física dos elementos se afirma como francamente descontinuísta” (Blanché: 1983, 58). À luz da ciência contemporânea não é possível saber com exactidão a posição e o momento de uma partícula. O saber trata-se de uma aproximação, de uma probabilidade. Quando se desce ao nível do elementar, a matéria *assume uma natureza ao mesmo tempo corpuscular e ondulatória*.

Ao nível atómico, o cientista questiona o significado *демиúrgico* do mundo. *Os átomos não são eternos. Podem ser criados ou destruídos pelo homem*, por intermédio de processos ou de energia. “Quando se juntaram as teorias de Heisenberg e Schrödinger, surgiu a possibilidade de criar e destruir partículas que antes não existiam. E isso está a ser feito neste momento!” (Glasshow cit. por Punset: 2009, 67).

No entanto, coloca-se ainda *a questão da matéria animada*. No início dos anos 50, o jovem biólogo Stanley Miller e a sua equipa, sintetizaram aminoácidos num alambique de laboratório e em seguida procuraram construir polímeros a partir destes aminoácidos. A replicação dos aminoácidos sintetizados não foi possível. Até hoje, ninguém é capaz de fazer a recriação da vida a partir de moléculas sintetizadas em laboratório. Eugene Chudnovsky (2009:56) questiona, “Por que é que aquela árvore cresce e cresce sem que possamos repetir esse processo em laboratório, a não ser germinando o seu próprio segredo impresso na semente?” Chudnovsky (2009:56) conta que em conversa com Stanley Miller o

²⁵ Se a velocidade na nave for muito inferior à velocidade da luz, o intervalo de tempo medido por ambos os observadores é aproximadamente igual, o que demonstra que o princípio da relatividade restrita contém a relatividade galileana. *As diferentes possibilidades de articulação decorrem dos pontos de vista e das escalas em que estamos a trabalhar.*

questionou, “«Por que é que não continuaste a criar proteínas e depois vida?». «Pensava que na semana seguinte seria capaz de o fazer, mas na verdade é que há quarenta anos que o estou a tentar e ainda não consegui.», foi a sua resposta.”

Podemos estruturar uma teoria da realidade a partir do reducionismo. Para explicarmos por exemplo o que é um copo, aprofundamos o olhar no sentido do universo infinitamente pequeno, da sua compartimentação sucessiva. No entanto, o contrário é também possível; partindo do universo infinitamente pequeno, como é que os átomos têm a capacidade de gerar a vida? E como se processa a criação de organismos vivos e complexos a partir das substâncias vivas mais simples? Quando, por este processo se criam os animais, nasce com eles a propriedade da cognição, “deste modo, em vez de serem unicamente o resultado de combinações aleatórias de átomos, conseguem realizar acções que têm uma finalidade. E tudo isto nos conduz outra vez à mente (...) retrocedendo-se chega-se às partículas fundamentais, embora nunca se chegue ao verdadeiro fundamento; e, por outro lado, acabamos por recriar a mente através da compreensão das coisas que estiveram na origem da vida e da evolução até se chegar à mente” (Morowitz²⁶ cit. por Punset: 2009, 50).

Em suma, a vida, o mistério da vida reside no facto de ser capaz de transmitir, geração após geração, o conhecimento genético impregnado na própria matéria animada. “Sem sombra de dúvida, os biofísicos e os bioquímicos criam moléculas novas, algumas delas inclusivamente muito complicadas, mas criar vida nova, isso ninguém é capaz de fazer” (Chudnovsky cit. por Punset: 2009, 55).

A vida revela assim uma inversão misteriosa da entropia. A irreversibilidade dos sistemas inverte-se. No entanto, a segunda lei da termodinâmica²⁷ remete toda a matéria para a degeneração, para o decaimento, e por fim, desaparecimento. A evolução espontânea de sistemas isolados traduz-se inevitavelmente num aumento da entropia. As casas fissuram e envelhecem e todas as estrelas se apagam. *Um dia, o Sol também acabará por se apagar.* Ilya Prigogine (2008) coloca a questão no contexto da própria instabilidade dos sistemas dinâmicos. Com a vida, “com a inscrição do código genético temos um tempo interno biológico que prossegue ao longo de milhões de anos da própria vida” (Prigogine: 2008, 68). A complexidade deste sistema dinâmico evolutivo aumenta sucessivamente, como “o cérebro dos primatas, cuja instabilidade permite amplificações e polarizações em todas as direcções” (Prigogine: 2008, 69). É esta preparação para a complexidade que nos leva a

²⁶ Harold Morowitz, biofísico, leccionou na Yale University e dedicou as suas investigações ao estudo da termodinâmica dos sistemas vivos.

²⁷ Segundo princípio da termodinâmica – a entropia do universo aumenta num processo contínuo e permanece inalterada num processo de equilíbrio.

reexaminar o segundo princípio da termodinâmica. Prigogine explica-nos que nos primeiros instantes o Universo era pequeno e muito quente. A sua evolução não se deu no sentido da degradação, mas do aumento da complexidade; as “estruturas apareceram progressivamente a todos os níveis, desde as estrelas e as galáxias aos sistemas biológicos” (Prigogine: 2008, 71). O autor acresce que a nível cosmológico, a realidade é muito mais complexa pois estão implicadas as dinâmicas da gravitação e da entropia. A questão continua em aberto, logo inconclusiva, devido à sua profunda complexidade.

Em suma, os jogos da matéria revelam uma diversidade que se reinventa continuamente e a vida ensina-nos que o futuro é um espaço em aberto, um sistema evolutivo que abarca dentro de si múltiplas possibilidades de articulação, processos de transformação, projectos de construção e desconstrução, criação autopoética.

“How does a project mature?
It is obviously a most mysterious,
imperceptible process.
It carries on independently of ourselves,
in the subconscious,
crystallizing on the walls of the soul.
It is the form of the soul
that makes it unique,
indeed only the soul decides
the hidden ‘gestation period’ of that image
which cannot be perceived
by the conscious gaze.”²⁸

Andrei Tarkovsky, July 3, 1975

²⁸ Tarkovsky, Andrei, et al, *Instant Light, Tarkovsky Polaroids*, 2004 Thames and Hudson, United Kingdom.

2ª PARTE

da percepção do visível à abertura ao real

“Porque eu sou do tamanho do que vejo
E não do tamanho da minha altura”²⁹

Alberto Caeiro, 1925

Dedicamo-nos neste capítulo ao exame da percepção, à possibilidade de exploração e reformulação das experiências do mundo através da imaginação. Em *A Poética do Espaço*, Bachelard descreve que “no reino da observação científica, com objectividade certa, a primeira vez não conta. A observação pertence ao reino das ‘várias vezes’” (Bachelard: 1989, 164) Neste contexto, Gonçalo M. Tavares refere que “as fórmulas que descrevem os factos, coisas ou comportamentos da matéria, são fixações numéricas de visões que não se alteraram, funções numéricas de visões confirmadas ou fixações quantitativas de múltiplas observações” (Tavares: 2013, 371).

A noção de progresso científico estará associada a um olhar exaustivo sobre o mundo que se apoia em instrumentos de observação. “É preciso inicialmente, no trabalho científico, psicologicamente, digerir a surpresa” (Bachelard: 1989, 164). O *espanto* corresponde à parte do mundo que escapou ainda à observação científica.

No universo artístico, o olhar múltiplo e repetido dá lugar a um *olhar primeiro*. “O olhar do imaginador é o olhar que se quer espantar; e se já se espantou com uma coisa e se volta a olhar para ela é porque se quer espantar de novo, provavelmente com um pormenor diferente” (Tavares: 2013, 372).

Artista e cientista aproximam-se e distanciam-se do referente. Poderão ainda apoiar-se em instrumentos ópticos ou mecanismos que possibilitam a alteração das escalas. No entanto, a atenção terá sempre dois estados ou “dois modos de pegar numa lupa” (Tavares: 2013, 373). O cientista, no encontro com o novo, procura repetir o olhar no sentido do

²⁹ CAEIRO, Alberto, *O guardador de rebanhos*, Edição Alma Azul, Coimbra 2007 (1925 ed. original), p.12.

discernimento do visível (da apreensão de padrões de discernimento). O artista, ao encontrar o novo, parte para outro lugar, mesmo que o espaço cartesiano seja ainda igual. A *imaginação* possibilita a construção de um espaço de liberdade em que o sujeito habita a matéria-prima e se mistura com o mundo “numa confusão de linhas que a racionalidade absoluta não pode entender” (Tavares: 2013, 374).

Como variação do tema *o homem lupa*, apresentamos um exemplo do poeta André Pieyre de Mandiargues³⁰ e outro de Merleau Ponty. O poeta aproxima-se da superfície e imerge no visível. Aquilo que vê é a “celebração do corpo” (Ponty: 2006, 6), é a aproximação do mundo *através da matéria* (*matéria do corpo, matéria do mundo*). Refere Ponty (2006:57) “Quando vejo, através da espessura da água, o quadradinho do fundo da piscina, eu não o vejo apesar da água, dos reflexos, vejo-o, justamente, através deles, por eles. Se não existissem estas distorções, estas listas de sol, se eu visse sem esta carne a geometria do quadriculado, aí sim, deixaria de o ver.” Refere Bachelard (1989:165) citando Mandiargues, “Aproxima-te da janela tentando não deixar a tua atenção demasiado voltada para fora. Até que tenhas sob os olhos um desses núcleos que são como quistos de vidro, ossinhos às vezes transparentes, mas quase sempre brumosos ou vagamente translúcidos, e de forma alongada que lembra a pupila dos gatos.” Através desse fuso vítreo, pergunta Bachelard, “em que se transforma esse mundo exterior?” (Bachelard: 1989, 165). A partir do quisto de vidro, o poeta, o sonhador, apresenta-nos um mundo em multiplicação. *Pegar uma lupa é prestar atenção*, mas, continua o autor, “prestar atenção não será possuir uma lupa? A atenção, por si só, é uma lente de aumento” (Bachelard: 1989, 165).

“Pois todo o universo se encerra em curvas; todo o universo se concentra num núcleo, num germe, num centro dinamizado. E esse centro é poderoso, pois é um centro imaginado. (...) E esse núcleo nuclearizante é um mundo. A miniatura estende-se até às dimensões de um universo. O grande, mais uma vez, está contido no pequeno” (Bachelard: 1989, 165). A relação entre o universo infinitamente pequeno e o imenso é consonante e a aproximação poética permite a transposição do espaço intermediário. Nós, continua o autor, “estamos presos nos embaraços da dialéctica do profundo e do grande; do infinitamente reduzido que aprofunda ou do grande que se estende sem limite” (Bachelard: 1989, 185)

Reduzindo o olhar, fechando os olhos, escutamos ainda de outra maneira, aproximamo-nos de outra forma da *matéria*. O “ouvido sabe que os olhos estão fechados, sabe que a responsabilidade do ser que pensa, que escreve, está nele” (Bachelard: 1989, 186).

³⁰ André Pieyre de Mandiargues, poeta e escritor, concebe o livro *Métamorphoses (poema em prosa L'oeuf dans le paysage)*, do qual Bachelard retira o exemplo indicado.

Relembramos o poeta René Daumal que nos ensina a ouvir com outras formas de atenção: “Escuta bem, contudo. Não as minhas palavras, mas o tumulto que se eleva em teu corpo quando me escutas.” (Daumal Cit. por Bachelard: 1989, 186) A *imensidão íntima* constitui-se no *sujeito*, está em nós, no “movimento do homem imóvel.” (Bachelard: 1989, 190) *O mundo aprofunda-se no ser humano* e “quando vive realmente a palavra *imenso*, o sonhador (...) já não é prisioneiro do seu próprio ser” (Bachelard: 1989, 200). O homem é um ser vasto. O “destino poético do homem é o de ser o espelho da imensidão; ou, mais exactamente ainda, a imensidão vem tomar consciência de si mesma no homem” (Bachelard: 1989, 201).

Conduzidos pelas mãos do artista Paul Klee (2006), deparamo-nos também com essa tomada de consciência. Entre o homem e o visível, há uma inversão do olhar: “senti várias vezes que não era eu que olhava a floresta. Senti, certos dias, que eram as árvores que me olhavam, que me falavam... Eu estava lá, à escuta... Creio que o pintor deve ser trespassado pelo universo, e não querer trespassá-lo... Aguardo ser interiormente submergido, enterrado. Eu pinto, talvez, para me emergir” (Klee cit. por Ponty: 2006, 29).

O escultor Alberto Carneiro (2007) revela também uma relação profunda entre o corpo e a paisagem. Na obra «Das Notas para um Diário e Outros Textos» escreve, “em mim mesmo, paisagem e natureza são entidades que podem coincidir como circunstância de me ver projectado para fora, enquanto vontade de me (re)conhecer para dentro, nessa fusão e metamorfose de me ser outro nelas” (Carneiro: 2007, 173). No acto de criação, a pessoa “é projectiva de si mesma, isto é, dá criação poética trabalhando fundamentalmente com ideias (...) essas ideias nem sempre podem ser definíveis por palavras, pois as correspondentes substâncias pertencem às configurações da pintura, da escultura, da música, da poesia. E não é por acaso que me refiro à poesia, onde se trabalha também com a palavra. É que a palavra funciona aqui de outro modo, como os materiais da pintura, da escultura e da música, como *poiesis*” (Carneiro: 2007, 179).

A criação poética, enquanto acto artístico, revela-se no ponto de convergência “das coisas partilhadas pelas diferentes artes (...) mas que é também o ponto de infinita divergência entre todas elas” (Sousa Dias: 2014, 58). Também na poética pessoana se revela um sentir tudo de todas as maneiras, sentir a existência velada do outro em nós. Bachelard, através de um processo de recolha de poemas, prosas poéticas e documentos literários, questiona-se: “Ora, por que os actos da imaginação não haveriam de ser tão reais quanto os actos da percepção?” (Bachelard: 1989, 166).

As reflexões bachelardianas sobre a natureza da imaginação são inclusivas, no sentido em que o sonhador, ao estar imerso no seu devaneio, não está mais perante um mundo que se classifica ou normaliza, mas um universo de possibilidades e de acolhimento. O fazer artístico abre caminho para a articulação de todos os possíveis.

A poesia “é *poiesis*, é um fazer, porquanto é um dizer que não diz, que não é uma forma diferente de dizer, a realidade dada, mas que antes faz ou cria a realidade que diz” (Sousa Dias: 2014, 34) Acrescenta o autor que “desse ponto de vista a poesia diz sempre mais do que diz e é esse mais, esse objecto do dizer impossível no entanto de ser dito, o que a poesia verdadeiramente diz” (Sousa Dias: 2014, 34). Retomamos o *ponto de convergência* das diferentes artes. Cada arte é expressão desse *indizível*, “um excesso de ser no ser como indizibilidade sensível do ser” (Sousa Dias: 2014, 35). Remetemo-nos ao princípio da poesia para uma *articulação do sentido*, uma articulação que “não seja unicamente verbal e que a linguagem ultrapasse infinitamente a linguagem” (Nancy: 2013, 6). Sigamos as palavras de Sousa Dias (2014:34), “é certo que desde sempre, e como se disse, a pintura partilha com a poesia e com todas as artes a poeticidade (silêncio do ser) da sua «referência» ontológica.”

O que significa esse *silêncio do ser* ou esse *excesso de ser no ser*? O que significa *esse ponto de convergência (e de infinita divergência)* entre todas as artes? O fazer artístico, “o enigma da arte estará nisso: fazer do medo desconhecido – melhor: do medo *do* desconhecido – o seu motivo secretamente inspirador: sons e imagens, se posso dizê-lo outra vez, que nos assombram. A arte não passou, não passa «da idade do medo». Mas, precisamente por isso, ela tem algo a ensinar aos homens que visivelmente não sabem o que fazer com o medo (com o medo primordial) que os domina e os divide em dominados e dominantes” (Maia, et al: 2010, 36).

Partimos do olhar, do exame da percepção, para dar lugar à imaginação (e à criação poética) enquanto possibilidade de criar realidade e de abertura o mundo. Cientista e artista são unos ao situar-se neste ponto de *infinita convergência de ser-se humano*. O acto *poiético* é inerente ao *sujeito*. A articulação entre a razão e a imaginação retoma a questão da abertura do ser humano ao mundo. “Porque pensar também é mudar de posição relativamente à própria linguagem. *Não olhar sempre da mesma maneira* para as palavras” (Tavares: 2013, 46).

Na obra *Os Passos em Volta*, Herberto Helder (2013) dá-nos também um exemplo que nos permite compreender a importância desta articulação. O poeta conta-nos a história de um

pintor que tinha um aquário onde vivia um peixe vermelho. À medida que o tempo passava, o peixe começou a tornar-se negro, uma negritude que nascia de dentro para fora. O negro ficava cada vez mais negro, um nó preto que crescia por detrás da cor encarnada. O problema do artista era que, querendo ser fiel ao referente, não sabia o que fazer da cor preta que se formava no real. “Ao meditar sobre as razões desta mudança exactamente quando assentava na sua fidelidade, o pintor supôs que o peixe, efectuando um número de mágica, mostrava que existia apenas uma lei abrangendo tanto o mundo das coisas como o da imaginação. Era a lei da metamorfose. Compreendida esta espécie de fidelidade, o artista pintou um peixe amarelo” (Helder: 2013, 21).

Sob o signo do movimento, Gonçalo M. Tavares (2013) dá-nos também um exemplo de articulação que tem como base *duas linhas paralelas*. Uma é feita pelo metal do instrumento, a outra é feita pelos pontos de terra que se lançam no ar através de um movimento manual, feito pelo homem. As duas linhas acabam por se encontrar, não no infinito, mas num instante logo a seguir, no momento que a linha de terra se desfaz em pequenas partículas e recai sobre o instrumento metálico.

Em suma, uma mesma linha junta a imaginação e a racionalidade das geometrias euclidiana e não euclidiana: um traço que se desfaz em partículas de terra. O ponto de encontro é a própria transformação.



fig. 3 – *Campus de Treino – Exercícios Gimnásticos de Espaço*, Os Espacialistas, 2011.

© Os Espacialistas

da metamorfose

“O poeta como muitos outros, sonha atrás da vidraça. Mas no próprio vidro descobre uma pequena deformação que vai propagar a deformação do universo.”³¹

Gaston Bachelard, 1957

O questionamento acerca da intimidade da matéria abre espaço, tal como abordámos anteriormente, para a criação de um debate entre matéria e forma. Neste contexto, o devir da matéria constitui-se através de um fenómeno organizacional ou de uma propriedade emergente e colectiva da própria matéria. A forma decorre da acção material de umas matérias sobre as outras.

A complexidade do problema aumenta com a diferenciação entre a *matéria inanimada* (*matéria sem vida*) e a *matéria viva*. Refere Bachelard (1990:86) “Nunca se pode esperar surpreender a vida no *simples* já que parece solidária de uma organização complexa. Haverá uma característica dominante da vida em geral? (...) O pluralismo da materialidade da vida é tão grande que implica incluir uma pluralidade nos processos vitais. Os problemas biológicos não se esclareceriam, nem sequer se indicariam, pela concepção de um fluido vital que destilaria na matéria, que animaria a matéria.” No plano da matéria viva, a actividade da vida está impressa na *força vital* que determina as suas condições de formação. O fundo de vida exerce-se no domínio da sua composição e tem uma capacidade de (re)criação auto-constituente. Deste modo, o exercício da vida é profundamente *autopoiético*³².

³¹ BACHELARD, Gaston, *A Poética do Espaço*, Martins Fontes, São Paulo, Brasil, 1989, p.165.

³² O termo *autopoiesis* foi desenvolvido pelos biólogos e filósofos chilenos Francisco Varela e Humberto Maturama. Este termo designa a capacidade de criação inerente aos próprios seres vivos e a autonomia da organização constituinte dos sistemas vivos.

A matéria inanimada *per se*, quando comparada com o fenómeno da vida, não tem a capacidade inerente de inversão da entropia. Refere Bachelard (1990:44), “É necessário um vulcão para provar que o laboratório da Terra está ainda, nas profundezas, em actividade.”

No entanto, o exercício da matéria viva decorre da articulação (de uma profunda interacção) com a matéria inanimada. “Os fenómenos da vida (...) reintroduziram os fenómenos químicos no planeta materialmente adormecido, tornado quimicamente inerte. A planta é um alambique, o estômago é uma retorta. Com os seres vivos, parece que a Natureza se ensaia para a facticidade” (Bachelard: 1990, 44). Na linha bachelardiana, é a partir da própria complexidade da vida que se criou o homem racional, e com ele, o estado cultural. Da acção racionalista do homem, decorre a ciência da transformação da matéria. As relações entre a matéria (viva ou inanimada) são assim dinamizadas pelo próprio homem.

Neste contexto, introduzimos duas investigações científicas (duas formas de aproximação da intimidade da matéria) que foram desenvolvidas ao longo deste trabalho.

A primeira investigação científica (*Vidro vermelho cobre por spray pirólise*³³) articula a transformação de matérias inanimadas por acção do calor. O debate desenvolve-se em torno da formação de uma cor específica decorrente das transformações da matéria e em conformidade com um modelo de construção.

Salienta-se, no entanto, que o verdadeiro atributo da cor é ainda mais complexo pois resulta da articulação entre a matéria do mundo e o nosso olhar. A construção da cor depende profundamente da percepção do fenómeno. Retomamos as palavras de Bachelard (1990:235), “Efectivamente, vamos propor uma instância filosófica nova: a da *cor construída*. E antes do exame desta noção, o filósofo pode declarar que será sempre um desvio inútil porque será sempre necessário voltar aos problemas filosóficos da cor percebida (...) Mas o nosso debate (...) é acompanhar o deslocamento do problema da substancialidade de uma qualidade.” No contexto de uma investigação científica, “o químico pensa a cor baseado no próprio modelo que guia a sua criação” (Bachelard: 1990, 235).

A actividade racionalista do cientista é manifesta. Vejamos o exemplo da nossa investigação: o cientista pretende criar uma cor vermelha cobre nos substratos de vidro. A cor é estruturada racionalmente antes de se iniciar o procedimento experimental. Bachelard

³³ A investigação é apresentada sobre a forma de relatório científico em anexo.

(1990) fala-nos da capacidade de criação de uma *cor escrita*. Os reagentes definem-se em função dos produtos de reacção que se pretendem obter.³⁴ O reagente (acetato de cobre) deposita-se na superfície do vidro (por spray pirólise³⁵) e a reacção ocorre devido à acção do calor (de uma temperatura difícil de definir³⁶). A cor (o vermelho cobre) apenas se anuncia após a pirólise. Neste processo, os iões de cobre Cu^{2+} reduzem-se³⁷, ou seja, transformam-se em nanopartículas³⁸ Cu. No entanto, *quando ocorre uma redução é sempre inerente uma oxidação*³⁹. A energia transita de umas matérias para as outras. Na verdade, a energia modifica a matéria.

A luz é energia (*constituída por fotões - corpúsculos ou partículas elementares*) que se propaga (*através de ondas electromagnéticas*) no espectro do visível (Tilley: 2000). Como fonte de energia, a luz modifica a matéria e é ao mesmo tempo através dela que discernimos o visível. Mas é também através dela (e da sua ausência) que apreendemos o invisível. De resto, esta é sempre uma qualificação que decorre da relação com o olhar do ser humano.

A maneira ontológica clássica de enunciar a propriedade da cor do cobre seria: *o cobre é vermelho alaranjado*. No entanto, os iões de cobre têm cores que variam de acordo com vários factores, entre eles o seu estado de oxidação. Os iões Cu têm vibrações características (ou seja, frequências de vibração e comprimentos de onda) que correspondem a uma determinada cor. O espectro de absorção dos vidros rubi de cobre apresenta um pico de absorção situado nos comprimentos de onda na ordem de grandeza dos 560 nm (Navarro: 1991). O olho humano apreende esta frequência de vibração como cor vermelha. No caso dos vidros coloridos com iões de cobre Cu^{2+} , a cor percebida é azul turquesa e esta cor

³⁴ Neste caso, uma das possíveis fórmulas químicas é:

$\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{CuO} + 2(\text{CH}_3\text{COOH}) + \text{H}_2\text{O}$

³⁵ O conceito pirólise advém do grego (pyrós: fogo + lysis: dissolução) e consiste numa reacção que ocorre por acção da temperatura.

³⁶ A definição de uma temperatura específica foi apenas alcançada após várias iterações (procedimento experimental em anexo).

³⁷ O cientista desenha a reacção de redução através da fórmula: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \Rightarrow \text{Cu}(\text{s})$, Como podemos observar, o ião de cobre recebe dois electrões (o elemento passa ao seu estado de oxidação natural, que é o estado de oxidação 0).

³⁸ As nanopartículas que caracterizam o vermelho rubi de cobre consistem em agregados coloidais com diâmetros que variam entre os 20 e os 50 nanómetros. A dimensão dos agregados depende de vários factores, como por exemplo a concentração do agente colorante e a temperatura de reacção. Se os agregados coloidais aumentarem, há um deslocamento da banda de absorção no sentido de comprimentos de onda maiores (a cor adquire uma tonalidade castanha). Se a temperatura for em demasia, há uma dissolução iónica na massa vítrea e a cor vermelha deixa de ser percebida. (Navarro: 1991).

³⁹ A reacção apenas ocorre na superfície do vidro que tem estanho. Há vários estudos que indicam a importância do estanho como agente que promove a redução do cobre: "In order to obtain a good copper ruby in industrial production the presence of tin is essential. Glasses melted without tin might turn blue due to the presence of Cu^{2+} ions, or yellow or yellowish brown and not strike during heat treatment" (Bring: 2006, 14).

é determinada por uma intensa banda de absorção situada entre os 780nm e os 810 nm (Navarro: 1991).

Neste contexto, “uma *substância* subtilmente estudada, revela-se uma *ex-stância*. As propriedades de uma substância são solidárias de uma experiência que a condiciona *exteriormente*. O único não tem propriedades” (Bachelard: 1990, 230). Retoma-se o conceito de *devir* como propriedade inerente da matéria.

Coloca-se também em questão o verdadeiro atributo da cor. Refere Bachelard (1990:231), “Já há vários séculos que se sabe que o ouro tem a cor que rejeita. Se se ilumina com uma luz branca⁴⁰, absorve todas as outras cores e emite o amarelo. Se se ilumina com uma luz privada de cor amarela, não seria amarelo.” Da mesma forma, o vermelho cobre que percebemos nas amostras de vidro corresponde à frequência de vibração que é ‘rejeitada’ pela própria matéria e que é depois apreendida pelo olho humano. “A cor não é, pois, um verdadeiro *atributo* da substância. É uma actividade – ou melhor, uma reactividade – que se manifesta em condições determinadas” (Bachelard: 1990, 232). A cor resulta de uma construção, “é de facto uma estrutura. E esta estrutura é seguida, fragmento por fragmento pelo químico” (Bachelard: 1990, 235).

No caso dos filmes finos, a definição da espessura das camadas é também condição para a determinação óptica da cor⁴¹. A cor de uma matéria decorre da sua própria extensão. Neste contexto, tomemos o exemplo do ouro que assume diversas cores de acordo com a espessura das camadas: “as lâminas finas não têm uma cor bem *definida*, não se lhes precisamente der uma espessura regular, uma *espessura bem definida*. Por transparência, eis um jogo de cores do ouro de acordo com as espessuras da folha: «o ouro é verde amarelo acima de 4µm; torna-se azul-verde, depois francamente verde cerca dos 2,7µm e finalmente rosa violácea cerca de 1,5µm»” (Bachelard: 1990, 229). A definição da espessura das lâminas finas é difícil de regular, ou seja, a determinação de uma cor específica depende da “conjugação da técnica de adelgaçamento (...) com uma definição meticulosa da espessura

⁴⁰ A luz branca contém todas as cores do espectro.

⁴¹ No contexto do mestrado em Arte e Ciência do Vidro (FBAUL, FCTUNL), a artista Marta Maranha desenvolveu também experiências científicas com filmes finos associados ao vidro. Neste caso, a difícil definição da espessura das lâminas finas revelou-se sobre a forma de diferentes cores e transparências na superfície do vidro. “Os espelhos de cobre são vulgarmente cor-de-rosa quando as lâminas são opacas, amarelo-esverdeado quando são translúcidas e azul quando adquirem uma espessura ínfima. Esta alteração da cor do cobre pode dar-se por vezes durante a sua deposição (...) estas lâminas espelhadas após aquecimento adquirem uma cor rosa-salmão devido à formação de nanopartículas (...) A visibilidade estende-se e produz-se na dualidade visível-vidente, o seu lugar é o da dispersão, a sua unidade é a da multiplicidade dos espelhos transparentes” (Maranha: 2014, 36). As diferentes cores e transparências das lâminas finas podem ser visualizadas em diversas imagens (págs. 8, 40 e 41) da respectiva dissertação.

da matéria” (Bachelard: 1991, 229). No caso do spray pirólise⁴², o filme fino sofre uma ‘metamorfose’ por acção do calor (e as nanopartículas do óxido metálico incorporam-se no vidro).

No contexto da investigação científica, indicamos ainda um outro exemplo que se relaciona com o condicionamento da experiência da matéria. Imaginemos que estamos a fazer um exercício invertido. Observamos uma amostra de vidro vermelha mas não sabemos qual é o agente que lhe atribui a cor. No entanto, o cientista sabe que os diversos espectros de absorção de vidros coloridos têm bandas de absorção e comprimentos de onda característicos. Há assim a possibilidade de observar os dados de medição e, a partir da respectiva racionalização da leitura, determinar a cor e a forma de coloração (determinar, por exemplo, se a cor se deve à formação de nanopartículas na superfície do vidro ou, por outro lado, à dissolução iónica na massa vítrea). Trata-se de outra forma de olhar e compreender uma matéria da qual se prevê racionalmente a cor. *Trata-se de inferir a matéria a partir do registo da sua acção.*

Num encadeamento transversal, retomemos Bachelard (1990:238), “com a caneta na mão, diante da folha em branco, o químico moderno sonhou desenvolver fórmulas que deveriam, se o laboratório pudesse realizar os seus projectos, construir uma cor determinada.” Em suma, há para a cor, vários caminhos possíveis de racionalidade.

A segunda investigação científica que aqui apresentamos (*Biodeterioração do Vidro Contemporâneo*⁴³) aborda as articulações entre a matéria viva e a matéria inanimada. Neste caso, o cientista não projecta a fórmula química da reacção. O trabalho científico foca-se, por outro lado, num exercício de observação da própria vida, do seu movimento de (re)criação.

O cientista selecciona duas espécies de fungos⁴⁴, coloca-as sobre as amostras de vidro e observa o seu desenvolvimento. Depois, passado um determinado intervalo de tempo, recolhe as amostras para observação. O cientista observa primeiro as superfícies impregnadas de vida e depois remove o ecossistema da superfície. A metodologia é detalhada tendo como base um suporte científico comprovado, *inúmeras vezes comprovado* na comunidade científica.

⁴² A determinação da espessura de camadas com morfologia e estrutura adequada depende de vários factores, como os reagentes utilizados e a sua concentração, a temperatura e a própria dimensão das partículas pulverizadas na superfície da amostra (Enescu, et al: 2008).

⁴³ Optou-se por colocar o relatório científico em anexo.

⁴⁴ As espécies seleccionadas foram *Aspergillus* sp. e *Penicillium* sp.

As observações seguem também várias possibilidades de racionalização dos fenómenos. Tal como na investigação anterior, desenvolve-se um exercício que decorre entre a observação das amostras e a interpretação dos dados de medição.

O microscópio óptico permite-nos aceder com o olhar a escalas que se aproximam do universo infinitamente pequeno. As observações efectuem-se nas ordens de grandeza micro (ou seja, mil vezes mais pequenas do que o milímetro). O cientista observa o crescimento do micélio e a formação de padrões de corrosão na superfície do vidro (como por exemplo, marcas de hifas ou formações de cristais). *O grande, mais uma vez, está contido no pequeno*, “no infinitamente reduzido que aprofunda” (Bachelard: 1989, 185).

O cientista recorre ainda a outras técnicas que lhe permitem aceder aos elementos ou às moléculas como complemento à observação da superfície das amostras. Tal como na investigação anterior, também é possível fazer um exercício invertido.

As ligações moleculares apresentam vibrações características. Através da espectroscopia μ -RAMAN⁴⁵, conseguimos aceder aos minerais ou aos cristais que se formam na superfície do vidro. O SEM-EDS⁴⁶ é também outra técnica que nos permite a observar a superfície das amostras e identificar os elementos (os átomos) que as constituem. Da análise dos espectros decorre a identificação de vibrações características da matéria. Trata-se de várias formas de apreender o fenómeno a partir da racionalização dos dados. Mais uma vez, *trata-se de inferir a matéria a partir do registo da sua acção*.

Face à compreensão desta organização energética da matéria, trata-se, retomando Bachelard (1990:208), de um “verdadeiro existencialismo da energia”. A relação entre o *ser* e o *ter* desconstrói-se, ou seja, a energia é absolutamente. Através de um exercício de reconversão, trata-se de dizer duas vezes a mesma coisa: “o ser é energia – e a energia é o ser. A matéria é energia (...) num mesmo instante, o reino do ter é transformado (...) a energia é a base de tudo” (Bachelard: 1990, 208).

⁴⁵ “The main spectroscopies employed to detect vibrations in molecules are based on the processes of infrared absorption and Raman scattering (...) Raman spectroscopy uses a single frequency of radiation to irradiate the sample and it is the radiation scattered from the molecule, one vibrational unit of energy different from the incident beam, which is detected (...) In Raman scattering, the light interacts with the molecule and distorts (polarizes) the cloud of electrons round the nuclei to form a short-lived state called a ‘virtual state’ (...) The energy changes we detect in vibrational spectroscopy are those required to cause nuclear motion” (Smith: 2005, 3).

⁴⁶ “O recurso à técnica de SEM-EDS (scanning electron microscopy – energy dispersive spectrometer) permite a análise da superfície e das secções transversais ao nível morfológico e obter informação relativamente à alteração da composição elementar” (Rodrigues: 2012, 10).

Ao dizermos, *o ser tem energia* ou *a matéria tem energia*, estamos a limitar a noção pois o princípio energético dos fenómenos impõe-se. Continua o autor a referir que “o fenómeno é a manifestação da energia, (...) as reacções químicas são relações de energia (...) é através das leis da energia que podemos explicar os fenómenos da matéria.” (Bachelard: 1990, 209).

No decorrer das investigações científicas o artista aprofunda o seu saber e reflecte:

A energia, as relações da energia, são a base de tudo. Tal como a química da matéria inanimada, também a química da vida é projecto de uma construção e desconstrução permanentes. Mas existe de facto uma diferença fundamental entre a química da matéria inanimada e a química da vida, uma diferença que se situa na parte do mundo que escapou ainda à observação científica. Num duplo olhar, cientista e artista dão lugar ao *espanto*.

O artista recolhe objectos que não representam as amostras finais ou os resultados científicos das experiências, mas sim o seu negativo (*o vestígio das acções dos cientistas*).

O tampo da mesa do vidreiro revela também um código de colocação das ferramentas, o registo primário da acção do fogo sobre a madeira. Tomemos em atenção o pensamento de Filomena Molder (2011:68) “Lembremos o provérbio hassídico «se queres encontrar o fogo procura-o nas cinzas», o que nos ensina a reconhecer no fogo uma força elementar que não se pode aprender senão nos seus efeitos.”

A repetição do gesto, a multiplicação do movimento até ao preenchimento do espaço (de um espaço que se ajusta à escala de um corpo humano), o ritmo da acção dá também lugar à obra. Um indício de resposta para este fazer artístico encontra-se na metafísica do tempo de Bachelard (1980:20) “Para pensar, para sentir, para viver, é necessário pôr ordem nas nossas acções, aglomerando instantes numa fidelidade de ritmos, unindo razões para fazer uma convicção vital.”

A dinâmica da respiração desenvolve-se *no sentido do talhe do ar com o próprio corpo*. O exercício do ser é um movimento natural de inspiração e expiração, de repetição do gesto. Neste sentido, o fazer artístico e a própria vida desenvolvem-se tendo esta acção como princípio. O sopro do vidreiro é um exercício de expiração que confere forma à massa vítrea. Do mesmo modo, o ser expira para o ar ou para outras matérias onde a própria matéria do sopro se condensa e transforma em pequenas gotas. Na procura da intimidade material, o artista encontra o gesto mais íntimo da escultura, *o esculpir de dentro para fora*, a partir da própria matéria do corpo.

Tal como *a matéria sai das prisões da forma*, o acto de esculpir não poderá estar limitado a acções de adição ou de subtracção. A própria desconstrução do espaço (inerente ao acto de esculpir) tem possível tradução a partir da respiração. “A matéria trabalhada, a matéria em trabalho, as matérias captadas na própria acção da sua mistura, tudo são lições de intimidade” (Bachelard: 1990, 26).

O aprofundamento da matéria é apenas possível através de um *duplo olhar* que supera a cisão que ocorre com a racionalização do conceito. À mortificação que decorre deste procedimento intelectual e analítico, opõe-se a “*vivificação* do poeta que retoma a harmonia do Todo Homem-Natureza” (Veiga Simão: 2010, 60).

Revela-se também, na linha nietzschiana de pensamento, que se é artista “à custa de sentir como conteúdo, como a ‘coisa em si’, aquilo que os não artistas chamam ‘forma’. Ao fazê-lo pertence-se indubitavelmente a um mundo invertido, pois doravante conteúdo, mas também a própria vida, passam a ser algo puramente formal” (Nietzsche cit. por Miranda: 2012, 67).

Coloca-se ainda a questão do movimento especular, de uma dupla face que espelha a paisagem. A superfície de aço é polida no sentido da relação com o próximo, onde o visível se desvela através da força de outros lugares. A diferença entre as faces espelhadas e as outras superfícies reside numa acção contínua sobre a matéria, no sentido de uma granulometria cada vez mais ínfima. É através da própria acção que um duplo espaço se mobiliza e acrescenta. Trata-se da imergência da fronteira na dissolução da fronteira, no aprofundamento do corpo através da sua própria extensão.

Relativamente ao movimento especular, refere Bachelard (2009:198), “pelo puro espelho do lago, o céu torna-se uma água aérea. O céu, é então para a água, uma comunhão na verticalidade do ser. A água que reflecte o céu é uma profundidade do céu. Esse duplo espaço mobiliza todos os valores do devaneio cósmico. Desde que um ser que sonhe sem limite, desde que um sonhador aberto a todos os sonhos viva intensamente num dos dois espaços, ele quer também viver no outro.”

O corpo não é apenas uma *imagem de*, mas sim uma expansão na qual a existência tem lugar⁴⁷. Já não se trata do fechamento do especular onde não interessa a face reflexiva do espelho, mas sim o outro lado. Refere Vilém Flusser (cit. por Miranda 2012:78), “a massa cinzenta do nitrato de prata é totalmente opaca. Ao contemplá-lo não vejo lá muita coisa. Para dizer a verdade: não vejo nada. Porque estou interessado nesse nada extremamente chato que vejo? Porque sei que ele é o responsável pelas reflexões que se dão na outra face (...) A nova arte o prova. Correm todos os caminhos, creio, na região que se estende a partir da outra face do espelho (...) Connosco começa uma nova época. A dos espelhos virados.” No entanto, “não se passa nada em nenhum lado do espelho, nas na relação entre uma e outra face (...) no espaço que os liga, na fina linha divisória (...) infinitamente delgada, que une e separa ao mesmo tempo a matéria e os simulacros” (Miranda: 2012, 78).

A racionalização do fenómeno decorre de múltiplas articulações. A coordenação das variáveis centra-se na actualização de diversos planos de referência. No entanto, toda a fenomenização é passível de interpretação. Da abstracção do fenómeno, decorre a conceptualização do mesmo. Por isso, o plano de referência estende-se a uma realidade que excede a outra face do espelho e que se forma através da relação com o próprio movimento especular.

A partir das intimidades da matéria, e das suas próprias potências de formação, o homem tem a possibilidade de superar a fragmentação que decorre de camadas e camadas de pedaços de imagens que se depositam no real. A memória poderá estar contaminada mas o ser humano é uno nas múltiplas possibilidades de ajustamento.

Italo Calvino (2006:112), na sua conferência sobre a «visibilidade» coloca a seguinte questão: “O poder de evocar imagens *in absentia* continuará a desenvolver-se numa humanidade cada vez mais inundada pelo dilúvio de imagens pré-fabricadas?” O modo como o autor procura uma saída traduz-se na sua obra literária. A estratégia adoptada passa por uma mudança de escalas. Trata-se de um olhar que abrange o mundo entre a cosmologia e a intimidade, entre o mundo infinitamente grande e o mergulho sobre a terra.

No livro «Palomar»⁴⁸, o olhar do observatório astronómico inverte-se na direcção da terra e percorre-se a distância excessiva entre o olhar panorâmico e o pormenor, como uma espécie de exercício sobre a potência infinita das possibilidades de ver. Entre o homem-multidão e a

⁴⁷ Refere Merleau-Ponty (2006:21) “O enigma consiste em que o meu corpo é ao mesmo tempo vidente e visível. Ele, que mira todas as coisas, pode também olhar-se, e reconhecer então naquilo que vê o «outro lado» do seu poder vidente. Ele vê-se vendo, toca-se tocando, é visível e sensível para si mesmo.”

⁴⁸ O título do livro corresponde ao nome de um conhecido observatório astronómico italiano.

individualidade distinta, regista-se o mundo; vê-se “as formas em que a areia humana se agrega tenderem para uma disposição segundo linhas de movimento, desenhos que combinam regularidade e fluidez com as marcas rectilíneas e circulares de um ancinho... E entre humanidade-areia e mundo-rochedo, intui-se uma harmonia possível, como entre duas harmonias não homogêneas: a do não humano, num equilíbrio de forças que parece não corresponder a qualquer desígnio; a das estruturas humanas, que aspira a uma racionalidade de composição geométrica ou musical, nunca definitiva” (Calvino: 2009, 102).

O ser humano aproxima-se do real, parte de uma visão panorâmica sobre o mundo e desce até ao ínfimo, ao particular, num encontro com a intimidade da matéria e da própria existência, numa condição que lhe é intrínseca e da qual tem uma profunda consciência. No entanto, o plano da nossa acção não poderá centrar-se apenas na observação, mas sim num exercício de evanescência da determinação consolidada ou num movimento de articulação em que uma nasce através da outra.

Na ausência de garantias teóricas ou estéticas, pensar, reflectir acerca das instâncias da matéria significa a necessidade de rearticulação constante do conceito.

Efectivamente, revela Ponty (2004:68), “o pensamento moderno oferece um carácter duplo de incompletude e de ambiguidade (...) concebemos todas as obras da ciência como provisórias e aproximativas.” São as múltiplas possibilidades de articulação que se revelam a partir do olhar, do exame da percepção e também daquilo que não se vê e que se infere a partir do seu vestígio (do negativo da sua acção). O ser humano percorre o universo (*faz-se ao mundo*) através da dialéctica da razão e da imaginação.

Diz-nos Bachelard (1989:155), “Subir a escada na casa da palavra é, de degrau em degrau, abstrair. Descer ao porão é sonhar (...) Subir muito alto, descer muito baixo é permitido ao poeta que une o terrestre ao aéreo.” O poeta não tem de se situar num “tal ângulo quase divino de visão. Basta-lhe assumir a sua condição humana intrínseca: o homem é o *nada a ser* (...) E dado que não escreve a partir do nada mas a partir do seu precário ser (...) esse poeta terá que subscrever, até fervorosamente, a sua contingência vital – o seu *a ser* – tanto como reconhecer, ao cabo, aquela pátria ou substância originária – o nada – do qual misteriosamente emergiu” (Jiménez: 1987,15).

O potencial humanizador da arte, de toda a *poiesis* trata-se de tomar consciência dos movimentos de articulação (da relação constituinte) entre o sujeito e o mundo. O sentido de habitar poderá ser sempre invertido. Relembremos: o exercício da matéria viva decorre da articulação (de uma profunda interacção com a matéria inanimada). Desse interacção,

resulta uma composição, um conjunto de articulações entre o sujeito e o mundo. O escultor inspira em silêncio a matéria diáfana, e depois de a sentir no fundo dos pulmões, expira lentamente, num exercício suave que confere forma formante e que se dissipa na paisagem. Exercícios de inspiração e expiração. Coexistência, dissolução e ligação. Articulação. Articulação de articulação. Impulso autopoético.

Por isso, a arte, ao invés de desistir, insiste. Traduz-se como uma força que não abandona o mundo e que nos ajuda a ver. Por isso, as formas, as próprias formas, diluem assim qualquer rigidez historicamente edificada; traduzem-se como conteúdo em acção, as formas são a própria matéria-devir, acentuam o profundo e o oculto, num caminho racionalmente difícil de desvelar. A forma é formante, trata-se de uma articulação e não de uma oposição.

Em suma, o canto do poeta, o canto do artista, o fazer do cientista, não são nada mais do que a voz intensa do explorador do mundo, de um mundo que nos ultrapassa em todas as circunstâncias e que no entanto nasce e floresce *de dentro-para fora-para dentro*.

“Podemos, talvez, continuar a chamar INDIVÍDUO à zona de maior densidade do conjunto nebuloso e complexo de processos, com as suas propriedades e intensidades, que converge para determinado corpo e dizer, por fim, eu sou uma nuvem voltei a perder o meu bilhete de identidade.”⁴⁹

Maria Ampá, 2011

⁴⁹ AMPÁ, Maria, *Maria Ampá*, Edição Mosca Bradu, Guiné Bissau, 2015

exposições

entre o tempo e a matéria

Laboratorio Chimico (MNHNC), Julho 2014





fig. 4 – vista geral da exposição *entre o tempo e a matéria*

fotografia: Carolina Thadeu

autoria: Margarida Alves



fig. 5 – metáforas temporais

ideia central da obra:

Desconstruir/construir o olhar através dos tubos dos cientistas;

Prolongar escultoricamente a antiga hotte do Laboratório Chimico;

Dialogar com a luz natural do espaço (pôr-do-sol, 18h-20h30).

materiais: tubos de vidro borosilicato, placa de madeira, espargos selvagens;

dimensões: 1,5m x 1,2m x 0,3m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 6 – pormenor de *metáforas temporais*

fotografia: Carolina Thadeu;



fig. 7 – dualidades

ideia central da obra:

Criar estrutura a partir da fragilidade da própria matéria: suspender/suportar o espargo verde no espargo seco; encostar dois espinhos (um espinho de cada espargo) para criar o elemento de contacto e sustentação estrutural;

Salientar a relevância conceptual do espinho.

materiais: espargo selvagem verde e espargo selvagem seco.

dimensões: variáveis;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 8 – poeta e cientista

ideia central da obra:

Materializar a dupla poeta-cientista;

Remeter as múltiplas possibilidades de articulação para o espectador;

Dialogar com a luz natural do espaço (pôr-do-sol, 18h-20h30).

materiais: tubos de vidro borosilicato modelados manualmente no maçarico;

dimensões: 1,5m x 0,4m x 0,05ms;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 9 – pormenor de *o fumo e o vento*

ideia central da obra:

Conceber uma relação (formal e conceptual) entre os múltiplos objectos de vidro e a chama que os modela;

Dar visibilidade à relação de absorção entre a luz e a matéria (absorção da radiação visível – negritude da matéria - através da acção da chama);

Formalizar/objectivar escultoricamente o processo de devir inerente ao fazer artístico (multiplicação da acção/do gesto do artista).

materiais: vidro borosilicato carbonizado (modelação manual no maçarico);

dimensões: variáveis;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 10 – vista geral da exposição *entre o tempo e a matéria*

fotografia: Carolina Thadeu

autoria: Margarida Alves

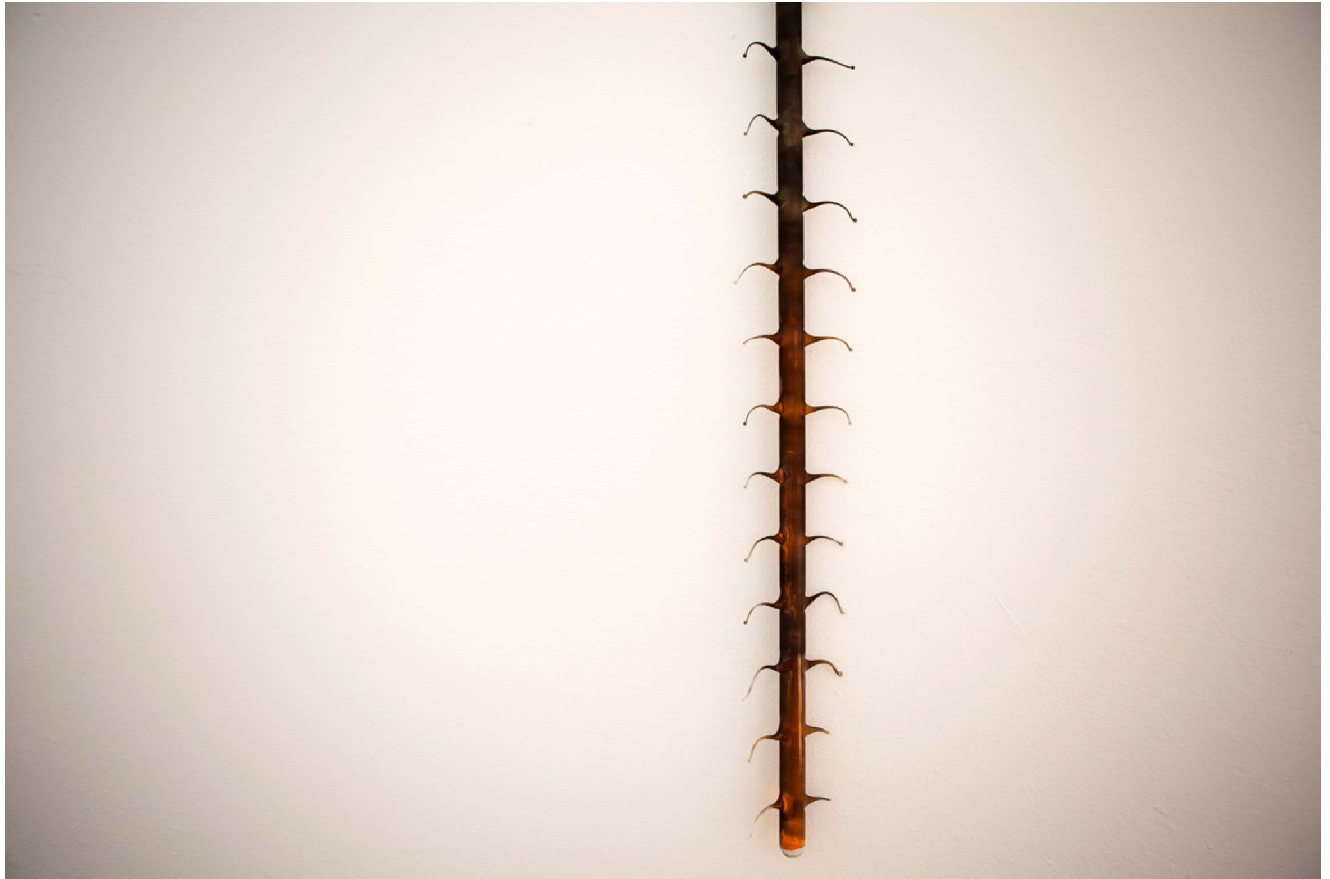


fig. 11 – pormenor de *rastos de fogo*

ideia central da obra:

Interligar a estrutura e a fragilidade da própria matéria;

Conceber uma articulação (formal e conceptual) entre os elementos estruturais naturais da exposição (espargos selvagens, folha de palmeira) e a chama que modela/estrutura a matéria vítrea;

Dar visibilidade à dupla relação de absorção e transmissão entre a luz e a matéria (absorção da radiação visível – negritude da matéria – transmissão da radiação visível – transparência da matéria).

materiais: vidro borosilicato carbonizado (modelação manual no maçarico);

dimensões: variáveis;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.

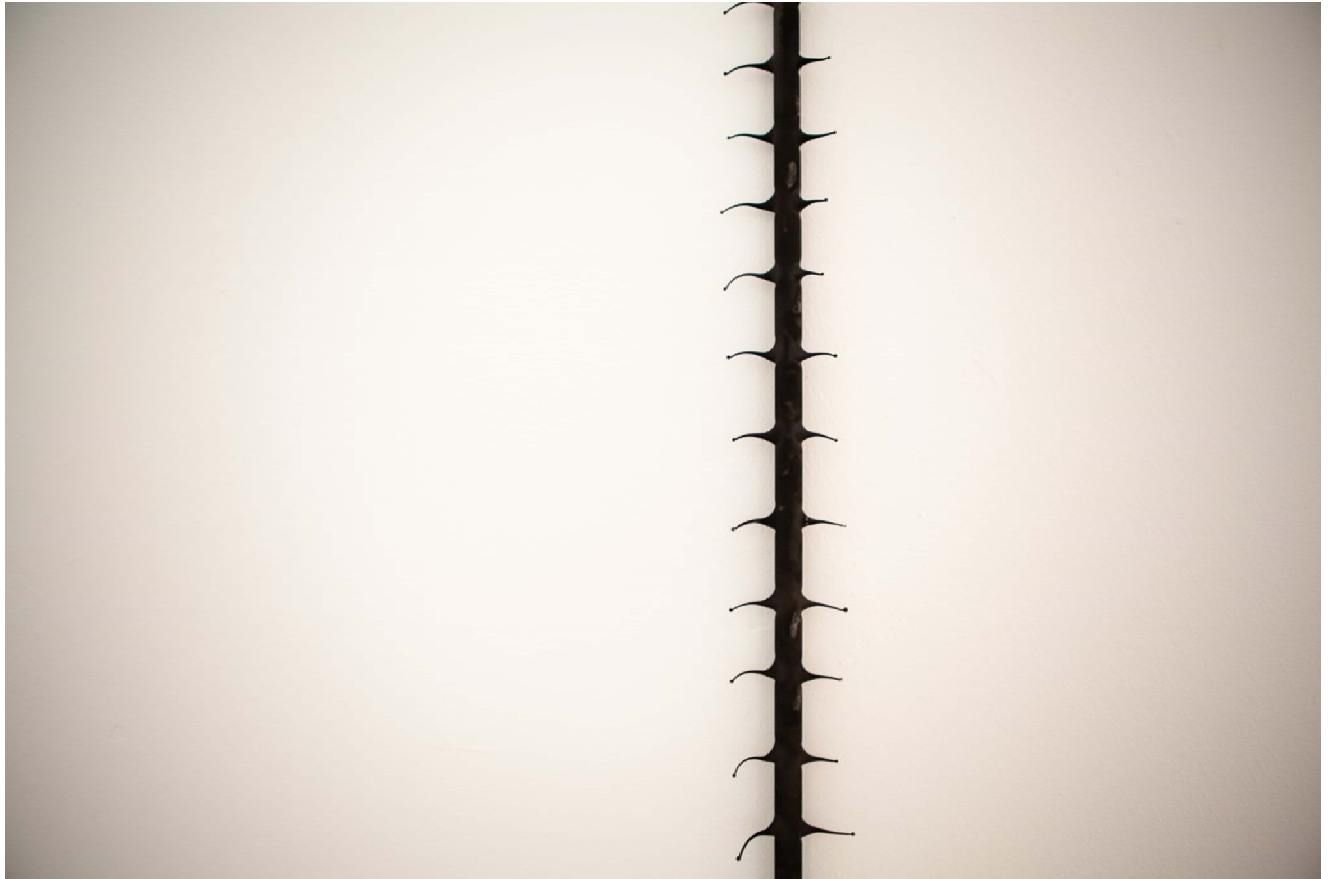


fig. 12 – pormenor de *rastos de fogo*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 13 – vista geral da exposição *entre o tempo e a matéria*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 14 – *são mãos de trabalho*

ideia central da obra:

Revelar o registo da acção do fogo sobre a madeira (revelar o código de colocação das ferramentas do vidreiro);

Fixar os vestígios da repetição do gesto dos artistas/vidreiros.

materiais: madeira (tampo da mesa do vidreiro);

dimensões: 0,8m x 0,6m x 0,02m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.

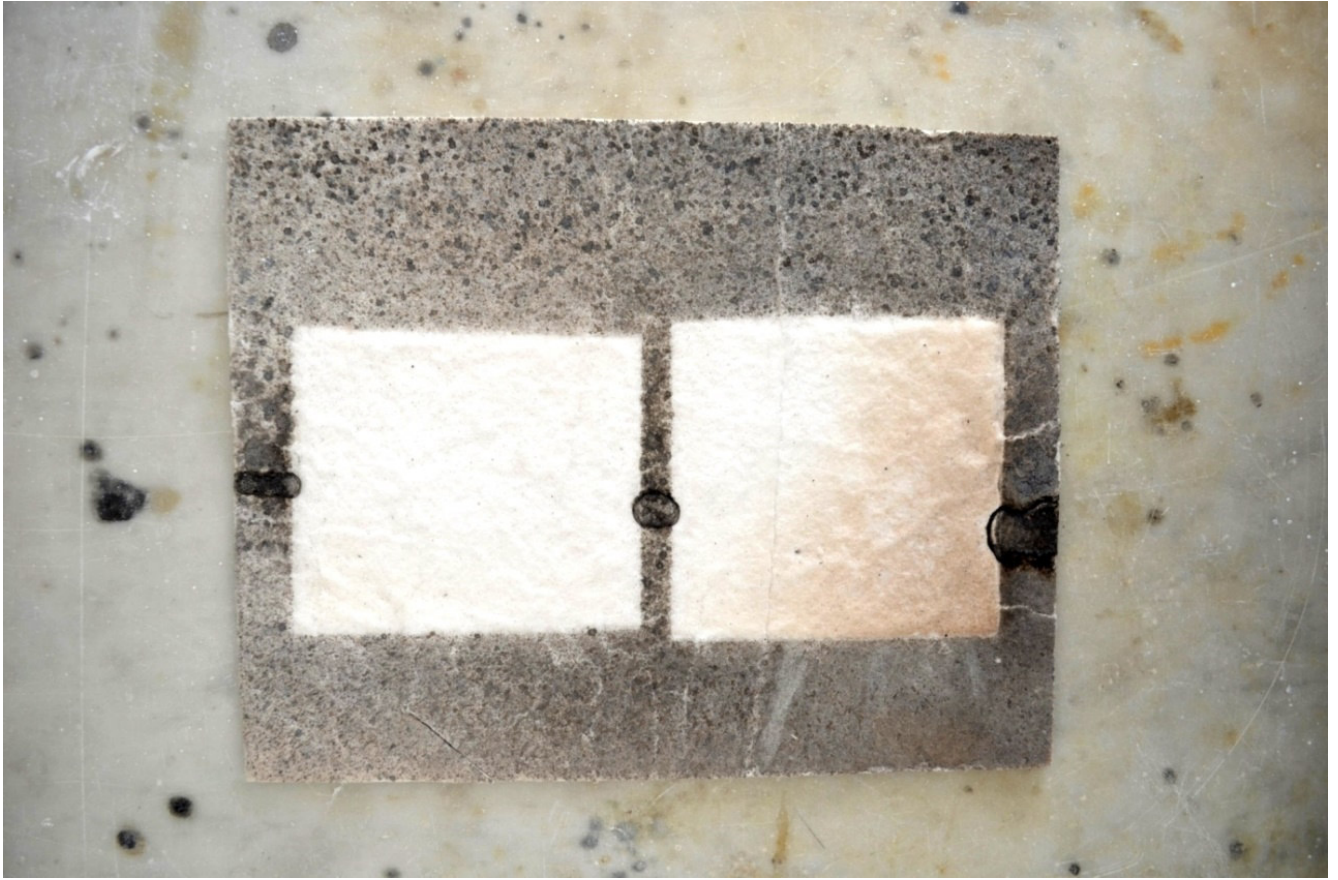


fig. 15 – da série *registos primeiros*

ideia central da obra:

Dar visibilidade ao espaço negativo das amostras científicas (o espaço onde as amostras foram colocadas durante o desenvolvimento experimental da investigação “*vidro vermelho cobre por spray pirólise*”);

Revelar o vestígio das acções dos cientistas.

materiais: manta geotêxtil;

dimensões: variáveis;

fotografia: Margarida Alves;

autoria: Margarida Alves.



fig. 16 – da série *registos primeiros*

ideia central da obra:

Dar visibilidade ao processo de devir associado ao fazer artístico e científico;

Dar visibilidade ao espaço negativo das amostras científicas (o espaço onde as amostras foram colocadas durante o desenvolvimento experimental da investigação “*vidro vermelho cobre por spray pirólise*”);

Revelar o vestígio das acções dos cientistas.

materiais: manta geotêxtil;

dimensões: variáveis;

fotografia: Margarida Alves;

autoria: Margarida Alves.



fig. 17 – na origem do tempo

ideia central da obra:

Formalizar/objectivar escultoricamente o desenvolvimento do processo inerente ao fazer artístico (multiplicação da acção/do gesto do artista);

Preencher um espaço que se ajusta à escala do corpo humano (relação antropomórfica da obra escultórica);

Revelar a ausência do corpo;

Revelar a presença da luz (diálogo da obra com a luz natural do espaço - pôr-do-sol, 18h-20h30);

Conceber uma articulação (formal e conceptual) entre as peças de vidro e os fungos (decompositores da matéria orgânica e inorgânica – interligação com a experiência científica de “*Biodeterioração de Vidro Contemporâneo*”).

materiais: vidro borosilicato (modelação manual no maçarico), estrutura de aço;

dimensões: 1,9m x 0,8m x 1,2m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.

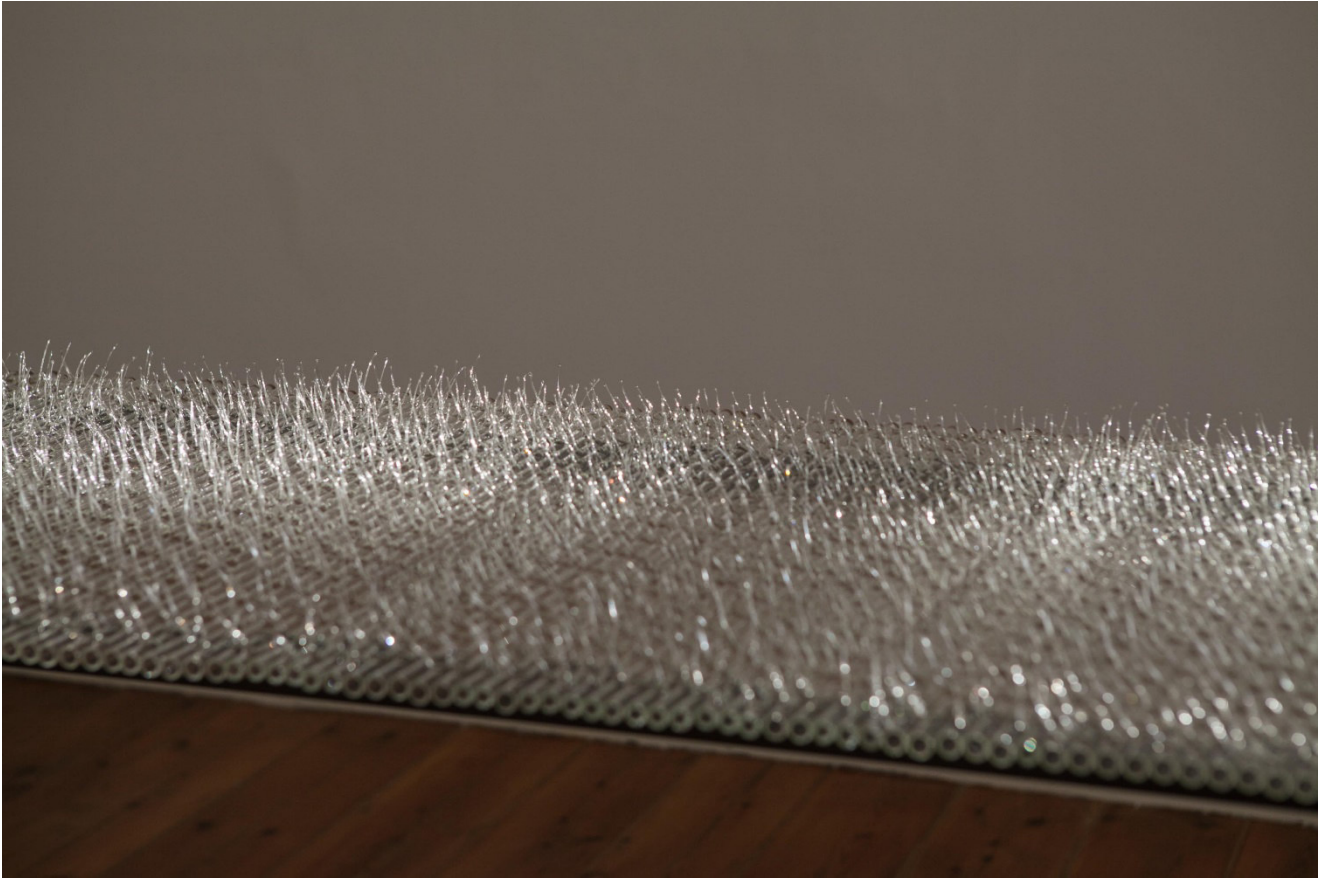


fig. 18 – pormenor de *na origem do tempo*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 19 – pormenor da *performance o sopro e o orvalho*

ideia central da obra:

Formalizar o processo de devir através da eventicidade da acção (a formalização escultórica do processo de devir é feita no momento constitutivo da performance);

Repetir o gesto, multiplicar o movimento através da dinâmica da respiração (associação da acção ao sopro do vidreiro);

Conferir forma através do sopro (expirar para dentro de um objecto de vidro oco; passado alguns minutos, o ar condensa dentro do objecto de vidro e transforma-se em pequenas gotas visíveis na parte inferior do objecto de vidro. Nota: duração máxima 5');

Esculpir de dentro para fora (a partir da própria matéria do corpo que se interliga com a matéria do mundo: oxigénio – dióxido de carbono – água – respiração – inspiração – expiração – condensação - sopro).

materiais: vidro borosilicato (modelação manual no maçarico), estrutura de madeira, papel de arroz;

dimensões: variáveis;

fotografia: João Mealha Costa;

autoria: Margarida Alves.

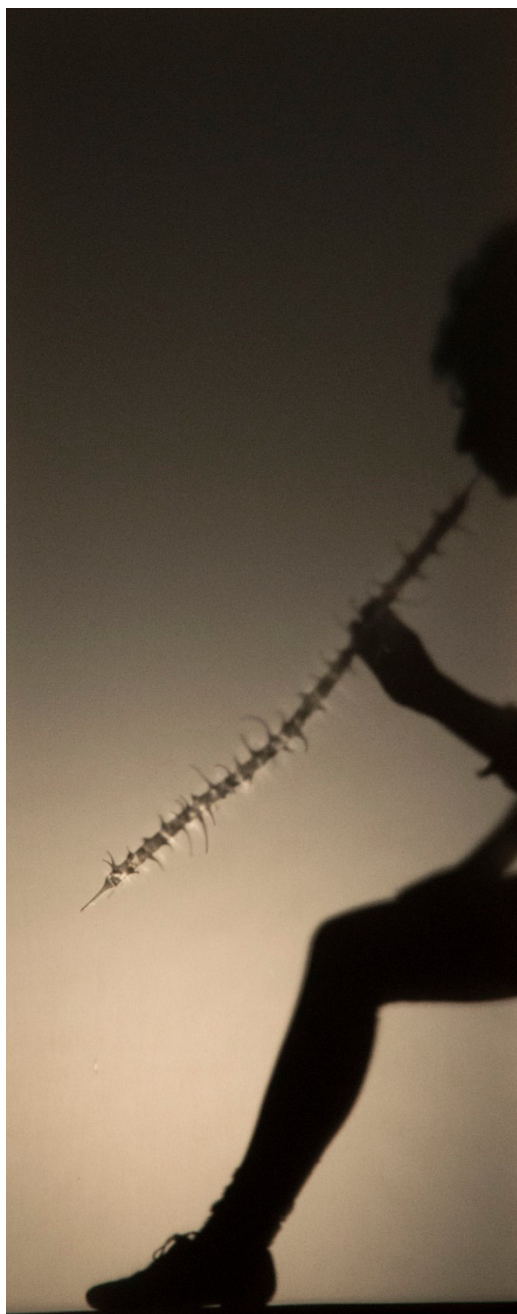


fig. 20 – pormenor da *performance o sopra e o orvalho*

fotografia: Nanico Dias;

autoria: Margarida Alves.

heterotopias

Sala do Veados (MNHNC), Setembro 2014



fig. 21 – *vista geral da exposição*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 22 – pormenor de *esculpir o fogo*

ideia central da obra:

Revelar o registo do movimento circular da massa vítrea incandescente sobre os papéis de jornal do vidreiro;

Fixar os vestígios da repetição do gesto dos artistas/vidreiros.

materiais: papel de jornal (utilizado na técnica de modelação manual do vidro);

dimensões: variáveis;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 23 – pormenor de *esculpir o fogo*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 24 – pormenor de *esculpir o fogo*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 25 – *impermanência*

ideia central da obra:

Conceber uma relação (conceptual e formal) com a obra *o fumo e o vento* (ver figuras 9 e 10) e a obra *esculpir o fogo* (ver figuras 22, 23, 24);

Dar relevância ao movimento circular associado ao fazer artístico do vidreiro (ver figura 28, obra *impermanência* no canto inferior direito da imagem);

Dar visibilidade à quebra/descontinuidade da linha de sombra projectada na parede.

materiais: madeira;

dimensões: 1,4m x 1,4m x 0,05m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 26 – o fumo e a sombra

ideia central da obra:

Interligar o círculo (conjunto de pontos internos da circunferência) e a acção do fogo (carbonização do círculo);

Conceber relações (conceptuais e formais) com a obra *impermanência* (ver figuras 25 e 28 - obra *impermanência* no canto inferior direito da imagem) e a obra *esculpir o fogo* (ver figuras 22, 23, 24);

Salientar a relevância simbólica do círculo.

materiais: placa de madeira (superfície circular carbonizada);

dimensões: 1,4m x 1,4m x 0,05m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 27 – alteridades

ideia central da obra:

Desconstruir/construir o olhar através dos tubos dos cientistas (articulação com a obra *metáforas temporais*, ver figuras 5 e 6);

Interligar a estrutura e a fragilidade da própria matéria (dar visibilidade ao esqueleto/coluna vertebral do corpo - relação antropomórfica da obra escultórica);

Salientar a relação formal e conceptual entre o esqueleto e o espinho (articulação com as obras *dualidades*, fig. 7, *suspensão entre o nada*, fig. 30, *horizonte paralelo*, figs. 33, 34, 35).

materiais: vidro borosilicato incolor e carbonizado (modelação manual no maçarico), chapa de ferro;

dimensões: 1,5m x 1,2m x 0,2m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 28 – *vista geral de exposição*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 29 – pormenor de *alteridades*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 30 – *suspensão entre o nada*

ideia central da obra:

Interligar a estrutura e a fragilidade da própria matéria (dar visibilidade ao esqueleto/coluna vertebral do corpo - relação antropomórfica da obra escultórica);

Salientar a relação formal e conceptual entre o esqueleto e o espinho (articulação com as obras *dualidades*, fig. 7, *alteridades*, fig. 27, *horizonte paralelo*, figs. 33, 34, 35);

Dar visibilidade à intersecção das linhas de sombra projectadas na parede (intersecção do arco de circunferência com a linha vertical).

materiais: vidro borosilicato incolor (modelação manual no maçarico);

dimensões: 1,2m x 0,6m x 0,6m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 31 – pormenor de *suspensão entre o nada*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 32 – *horizonte paralelo*

ideia central da obra:

Dar visibilidade à transitividade da matéria (a linha enquanto expressão do ritmo da acção através interligação do vidro carbonizado e do vidro transparente);

Salientar a relação formal e conceptual entre a obra e a linha do horizonte (visualização da obra à altura dos olhos - escala do corpo da artista);

Salientar a relação simbólica com o espinho.

materiais: vidro borosilicato carbonizado e incolor (modelação manual no maçarico);

dimensões: aproximadamente 13 m de comprimento (ao longo da extensão da parede norte da sala);

fotografia: Margarida Alves;

autoria: Margarida Alves.



fig. 33 – pormenor de *horizonte paralelo*(vidro carbonizado)

fotografia: Margarida Alves;

autoria: Margarida Alves

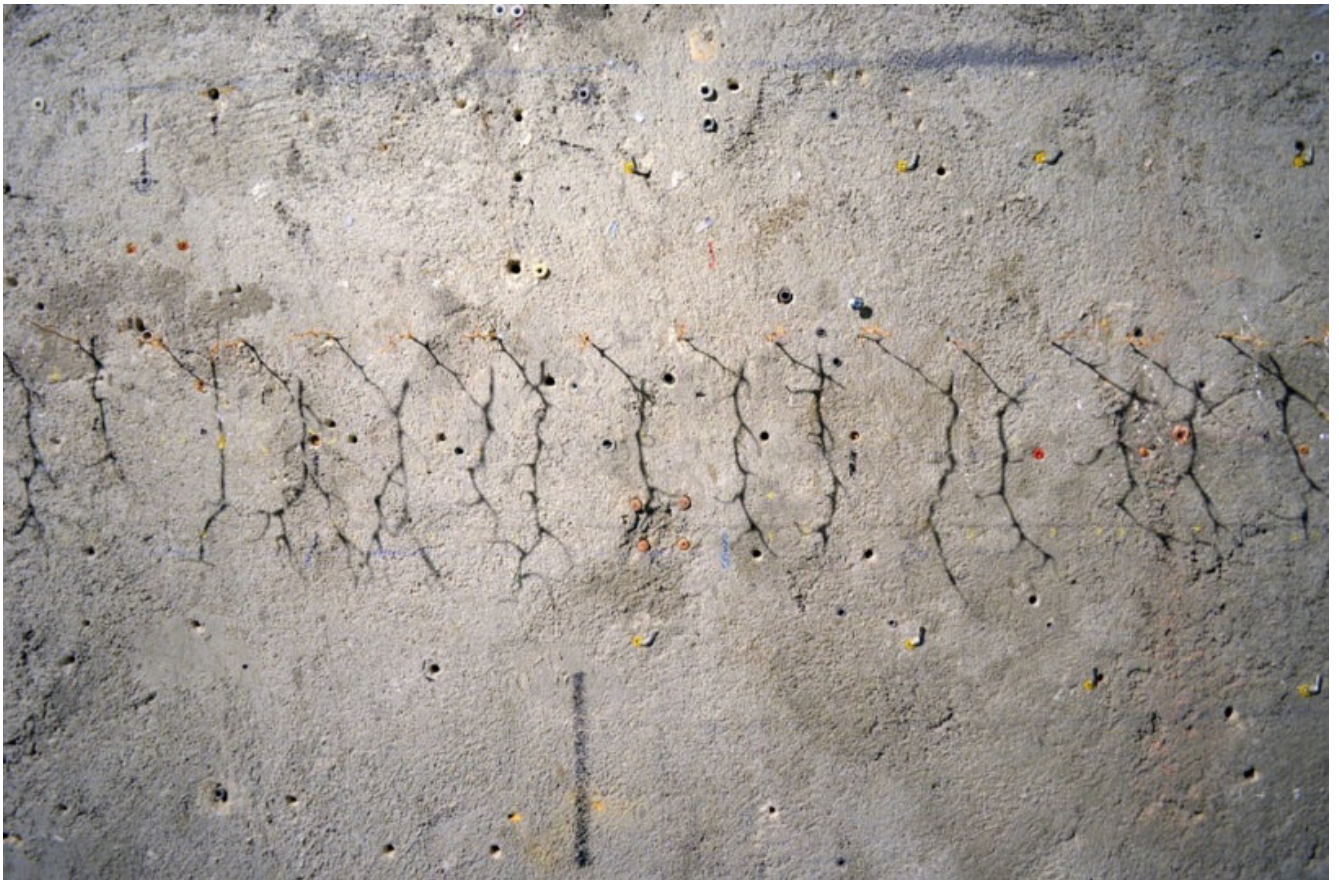


fig. 34 – pormenor de *horizonte paralelo* (vidro transparente)

fotografia: Margarida Alves;

autoria: Margarida Alves.



fig. 35 – superfície e profundidade

ideia central da obra:

Conceber uma articulação (formal e conceptual) com a obra *na origem do tempo* (ver fig. 17);

Estender/Prolongar a escala da obra *na origem do tempo* (a escala do corpo, associada à obra *na origem do tempo*, dá lugar à escala de uma mesa comprida – mesa de ceia);

Revelar a presença da luz (diálogo da obra com a luz do espaço);

Trabalhar o limite do esforço físico associado ao gesto do artista/vidreiro.

materiais: vidro borosilicato (modelação manual no maçarico), chapa de ferro;

dimensões: 3,0m x 0,6m x 0,8m;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 36 – pormenor de *superfície e profundidade*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 37 – *quo vadis*

ideia central da obra:

Revelar o movimento especular (que resulta de uma acção contínua sobre a matéria, no sentido de uma granulometria mais ínfima). Revelar o imergir da fronteira através da sua própria dissolução (de aprofundar o corpo através da sua extensão);

Possibilitar a entrada física do corpo humano no espaço da obra (a obra manifesta-se também enquanto passagem – portal);

Relacionar a escala do corpo humano com a escala da obra (verticalidade, relação antropomórfica);

Desconstruir o círculo.

materiais: chapas de aço;

dimensões: variáveis;

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 38 – *quo vadis*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.



fig. 39 – pormenor de *quo vadis*

fotografia: Carolina Thadeu;

autoria: Margarida Alves.

CONCLUSÃO

Entre a razão e a imaginação, o sujeito procura explorar a *matéria*. O aprofundamento científico do conceito possibilita o alcance de uma intimidade material que coloca em questão o próprio fazer artístico.

Da matéria devém forma. A matéria é constituinte, acrescenta-se na incompletude do saber. A própria forma traduz-se como matéria-devir, como conteúdo em acção. Por isso, a forma é formante, trata-se de uma articulação com o próprio conteúdo e não de uma oposição ao mesmo. A intimidade da matéria aumenta face à compreensão das relações entre a matéria e a energia. A matéria é a própria manifestação da energia. Tal como o espaço-tempo se revelam como o sistema de coordenadas da teoria da relatividade, o reino do ser resulta de uma articulação inseparável entre a matéria e a energia. Poderemos dizer, a matéria-energia é absolutamente.

O conceito aprofunda-se num duplo sentido que percorre o universo cosmológico e o infinitamente pequeno. Os limites perscrutam-se através das linhas rasto, dos vestígios da acção. A presença da matéria acentua-se à medida de uma ciência também constituinte. Trata-se de uma acção que duvida de si própria, de uma verdade que não exclui fissuras e que se centra nas múltiplas possibilidades de articulação.

A matéria habita-nos e entre a matéria animada e a matéria inanimada reside o mistério da vida, o facto de ser capaz de transmitir, geração após geração, o conhecimento genético impregnado na própria matéria animada. No entanto, a recriação da vida não é ainda possível a partir das moléculas sintetizadas em laboratório. Coloca-se a seguinte questão: Como é que a vida gera vida? Como expressar esse indizível?

O acto poiético possibilita a articulação que torna visível o indizível¹. Entre o homem e a matéria, há a possibilidade de inversão do sentido de habitar. O fazer artístico dá lugar à imaginação para a construção de um espaço de liberdade em que o sujeito habita a própria matéria.

¹ Tomás Maia fala-nos de um inominável tornado visível: “*A imagem não é o visível privado de palavra, mas a impotência de dizer (de nomear) tornada visível.*” (Maia 2009, 179)

Neste sentido, já não se trata apenas da mobilização de uma verdade relativa (oriunda de diversos pontos de vista dependentes do observador e do observado) ou da desconstrução de um espaço-tempo. Tal como a matéria-energia se define enquanto devir, o visível nasce a partir do próprio corpo, das suas potências de formação, dos seus impulsos de auto-criação e da sua articulação com o próximo.

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ANEXOS

Trabalhos Científicos

Red Copper glass by Spray Pyrolysis

ABSTRACT

Red copper colour in glass was possible to achieve by spray pyrolysis. An aqueous solution of copper (II) acetate (0,334M) was sprayed into glass substrates (commercial soda-lime silica float glass plates) at a specific temperature (450°C).

The float glass samples were sprayed in the tin and non-tin side. Red copper colour only appeared in the tin-side. Therefore, tin plays an important role in the reduction and/or nucleation of copper nanoparticles. Further studies should be done in order to understand the exact importance of tin in this process.

UV-Vis absorption spectroscopy was performed in order to confirm the presence of copper nanoparticles. It was possible to see an intense band that corresponds to typical copper nanoparticles absorption spectra ($\lambda=565$ nm).

From samples observations and spectra analysis, we infer that the colourization process is due to the formation of Cu^0 copper colloidal aggregates or nanoparticles. Therefore, there is an ionic dissolution of the colouring agent into the glass substrate and a reduction of copper.

The value of each layer thickness was calculated taking in account a 100% film deposition, being approximately 41,7 nm. However, further analysis (e.g. X-ray Fluorescence and Rutherford Backscattering Spectrometry) should be done regarding the glass composition and structure (before and after annealing) and to determine the films thickness.

1 - INTRODUCTION

Red glass is very difficult to produce but it has always been highly appreciated.

According to Bring 2006, Cadmium (Cd) based pigment has been used as the predominant glass colouring red pigment. However it is extremely toxic for humans and for the environment.

Therefore, it is very important to find acceptable alternatives to Cd colouring. For example, red glasses can also be obtained with the formation of metal colloidal particles, such as gold or copper nanoparticles.

Red glasses with gold and copper are difficult to produce as the colour depends on the reducing conditions as well as on the annealing temperature which determine the colloidal aggregation. Thin films technology can be an answer for these problems and will also allow us to colour glass with a very small amount of colouring agent. A better understanding of this process may help us to find some simple and less expensive solutions to red glass colouring.

Glass colouring

Glass colour appears when the incident light interacts with the material. According to Navarro 1991, the incident intensity is equal to the sum of the reflected, scattered, absorbed and transmitted intensity² (equation 1):

$$I_0 \text{ (incident intensity) } = \\ = I_r \text{ (reflected intensity) } + I_d \text{ (scattered intensity) } + I_a \text{ (absorbed intensity) } + I_t \text{ (transmitted intensity) }$$

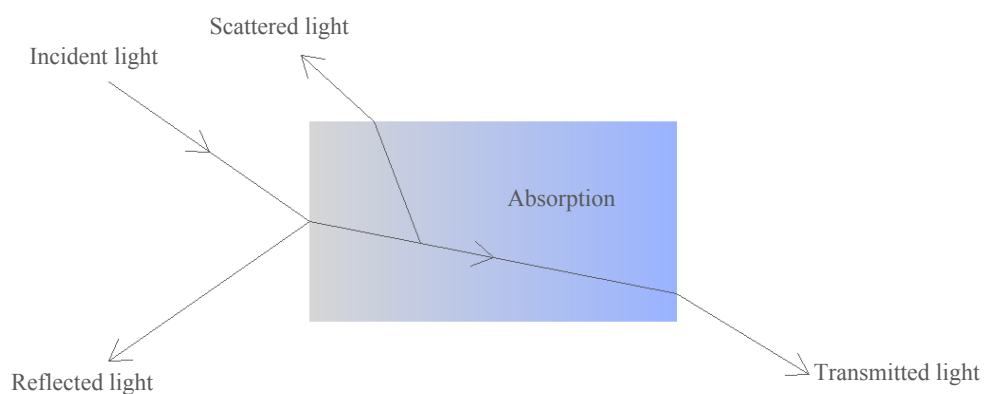


figure 40 – Light interaction with a translucent material

² This equation excludes the fluorescence phenomenon (when some of the absorbed light is re-emitted, usually at a lower energy level).

The incident light can be reflected at any surface and the light passing through the material can be scattered or absorbed (see figure 40). The light that leaves the material is the transmitted light (Tiller: 2000). The appearance of a solid is often related to reflection; if the surface is smooth the reflection is specular and if the surface is rough, the reflection is diffuse (the diffuse reflection component increases with the surface roughness). Scattering can also take place in glass (for example opal glass) and the material may become non-transparent or translucent. The light beam transmitted from a translucent material will also consist of diffuse and specular components.

According to Navarro (1991), glass colour is mainly related with the optical absorption phenomenon (in the visible spectrum). If the white light enters the material and if it transmits all the incident radiation in the same proportion, the material is perceived as colourless. On the other hand, if the light wavelengths are absorbed in different proportions and in a selective way, the material becomes coloured. This perceived colour is the result of the spectral components which pass through glass.

The glass optical absorption depends on several factors such as the sample thickness (l), the colouring agent concentration (c) and the molar extinction coefficient (ϵ) (that depends on the glass composition, light wavelengths and external variables such as temperature) (Navarro: 1991).

This dependence can be represented by the Lambert-Beer law (eq. 2 and eq.3):

$$T = \frac{I}{I_0} = 10^{-\epsilon lc} \quad (\text{eq. 2})$$

$$A = -\frac{\log I}{I_0} = \epsilon lc \quad (\text{eq. 3})$$

where I_0 is the light intensity entering the object and I is the light intensity which leaves the object.

Glasses are among the few materials that transmit light in the visible spectrum region, when the light strikes uncoloured glasses, almost all the wavelengths are transmitted in the same proportion as the incident light. In these cases, no colour is perceived by the human eyes (Navarro: 1991).

The main glass components are colourless and in order to produce colour we need to add colouring agents. According to (Tiller: 2000), glass can be coloured by ionic elements and colloidal particles.

The ionic elements generally used to colour glass are 3d transition metals or the 4f rare earths; they are usually present in very small quantities compared with the raw materials

and they are mixed in the glass raw materials. Many ions exist in several valences and they can give different colours to glass. These colours are due to transitions between electronic energy levels, which are due to an electron excitation from a ground state energy level to an excited-state by absorption of photons (Valeur: 2001).

Colloidal particles colours are “not due to light scattering, but rather to absorption by the particles, which cause an intense optical absorption band.” (Shelby: 1997, 205) Gold, phosphorus and copper ruby glasses belong to the group of glasses coloured by colloidal particles. In this case, the ruby colour is only developed after a heat treatment and the colour intensity depends on the thermal treatment and also on the concentration of the colouring components.

The colloids are formed due to the ionic metals reduction. This reaction is called striking and it occurs when the colourless glass substrate is reheated to the correct reduction temperature (Shelby: 1997). If the colloids density is high, the glass may become opaque instead of transparent.

Navarro 1991 refers that gold, phosphorous and copper ruby glass are originated by a specific nanoparticles size, with a diameter that varies between 20 and 50 nm, and the obtained colour depends on the size of the colloidal aggregates. The absorption spectrum of these ruby glasses is similar, however their wavelength of maximum absorbance and shape, depends on the size, shape and dielectric properties of the metal nanoparticles. Commonly gold nanoparticles and copper nanoparticles gave rise to absorption bands with a maximum around 530 nm and 565nm (Shelby: 1997), respectively. Navarro (1991) also indicates that when the colloidal aggregates grow, there is a displacement of the absorption band to higher wavelengths and the colour darkens (it becomes brown). If the colloidal particles diameter grows too much, the glass acquires a hazy aspect and even opaque.

In the case of red copper glasses, the colour may be attributed to copper colloids or colloidal crystals of Cu_2O : “Since both metallic copper and Cu_2O are often found in copper ruby glasses, it is possible that the colour arises from a combination of these species” (Shelby: 1997, 205).

Ruby glass colouration can be resumed in three main steps: ionic dissolution of the colouring agent into the glass; ionic reduction; colloidal aggregation (Navarro: 1991).

Tin Component

As mentioned above, ruby glass colouration only occurs if there is ionic reduction. Therefore, a reduction agent is essential in this process. Shelby (1997) notes that the

reduction reaction results from a redox reaction with other components of the glass or with an external reducing agent such as H₂.

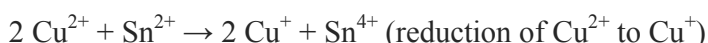
Several authors (e.g. Thompson: 2007, Bring: 2006, Haslbeck et al: 2005) refer the importance of tin as an essential reduction agent in red glass colouration.

Thompson (2007) refers that the first discovery about the importance of tin oxide to gold ruby striking colour was made in the end of the seventeenth century by Glauber and this discovery was then used for red glass manufacture in a factory in Potsdam. In 1685, Dr. Cassius published a book called *De Auro* where he described the gold ruby glass production. Dr. Cassius also realized the importance of tin oxide to gold ruby colour glass and enamels. According to Bring (2006), in the beginning of the 18th century, P. Ebell carried out an investigation about copper ruby glass and he concluded that tin and lead were essential elements to the production of glass red colour. P. Ebell refers that soda-lime glass can be used as a base glass for these experiments.

Bring (2006) also refers that in order to obtain a good red copper colour, tin presence is essential. Glasses melted without tin do not strike during the heat treatment, however when tin concentration is too high, glass becomes opaque.

Bring (2006) refers several studies regarding the importance of tin in red copper glass:

- Duran et al, 1983³ came to the conclusion that SnO has a protective role, preventing the disproportion of Cu⁺. According to this study, during heat treatment, two reactions take place simultaneously, as long as Sn²⁺ is present in the glass substrate:



Therefore, tin acts as a redox buffer, preventing a disproportional reduction to metallic copper.

- Ram et al, 1974⁴ refers that the reduction of Cu⁺ to Cu⁰ is retarded by the reduction of Sn²⁺ to Sn⁰. According to the author, the point where all Cu²⁺ has been reduced to Cu⁺ is called the “critical stage” and it lasts for 1-2 hours – as long as there is Sn²⁺ ions left in the melt. Afterwards, Cu⁺ is reduced to elementary copper and the glass will be ruined. Therefore, tin protects the cuprous ions in the melt from being reduced to elemental copper.

³ Duran Carrera, A. and Fernandez Navarro, J.M. *Colouring mechanism in copper ruby glass*. in *XIII International Congress of Glass*. 1983.

⁴ Ram, A., Prasad, S.N. and Srivastava K.P., *New conceptions on copper ruby glass. Part I-4*. Central Glass and Ceramic Research Institute Bulletin, 1974. 21: p. 1-23.

- Ishida et al, 1987⁵ suggests that Sn^{2+} promotes the formation of nuclei on which Cu^+ will deposit as Cu_2O . According to this study, Sn^{2+} reduces copper to the elementary state and that cuprous ions precipitate as Cu_2O . The elementary copper functions as nuclei on which Cu_2O can precipitate.

- Sensarma and Prasad et al, 1981⁶ observed that the Cu^+ concentration is the same in annealed glasses with or without tin; however glasses without tin do not strike. Researchers suggest that Sn^{2+} dislodges Cu^+ from Si-O-Cu^+ groups, and Cu_2O is formed.

As mentioned before, red colloidal colours strongly depend on the size distribution of the nanoparticles. This size distribution depends on several factors such as the duration and temperature of annealing, glass composition and also nucleating agents that influence the precipitation of nanoparticles. According to Haslbeck et al (2005), tin is well known to increase the speed which glass strikes red but the mechanism by which it acts is still a matter of discussion.

Tin presence is essential in float glass sheets industrial production. Most modern glass sheet is produced using the float process (float glass). In this process, the glass melt is carried from the glass tank directly onto the surface of a bath of molten tin. The molten glass floats in the bed of molten tin. The final float glass sheets contain a denoting concentration of tin in the underside (the surface which is exposed to the tin). Much of the dissolved tin is in the tin(II) state. (Shelby: 1997)

This ‘tin-surface’ can work as reduction agent. “The tin (II) ions are present due to diffusion into the glass from the molten tin bath used in producing float glass. This reaction is very specific to the ‘tin-surface’ and only occurs within the outer few micrometres of the glass surface” (Shelby: 1997, 207). Therefore, this process gives rise to the ability to reduce copper ions introduced from an external source.

Thin Film Deposition

Thin films deposition consists on the settlement of one or more layers - with a final thickness that ranges from the fraction of one nanometre to one micrometre - onto a substrate.

Deposition techniques can be either chemical or physical. Physical deposition techniques include physical vapor deposition (PVD), laser ablation, molecular beam epitaxy and

⁵ Ishida, S., Hayashi, M., Takeuchi, N. and Wakamatsu, M., *Role of Sn^{2+} in development of red colour during reheating of copper glass*. Journal of Non Crystalline Solids, 1987. 95/96: p. 793-800.

⁶ Sen Sarma, S. and Prasad, S.N., *Further studies on the role of tin in copper ruby glass. Part 2. Thermal treatment of SnO and Cu_2O* . Central Glass and Ceramic Research Institute Bulletin, 1981. 28: p. 89-93.

sputtering (Perednis et al: 2005). Chemical deposition techniques consist in gas-phase deposition methods and solution techniques (fig.3).

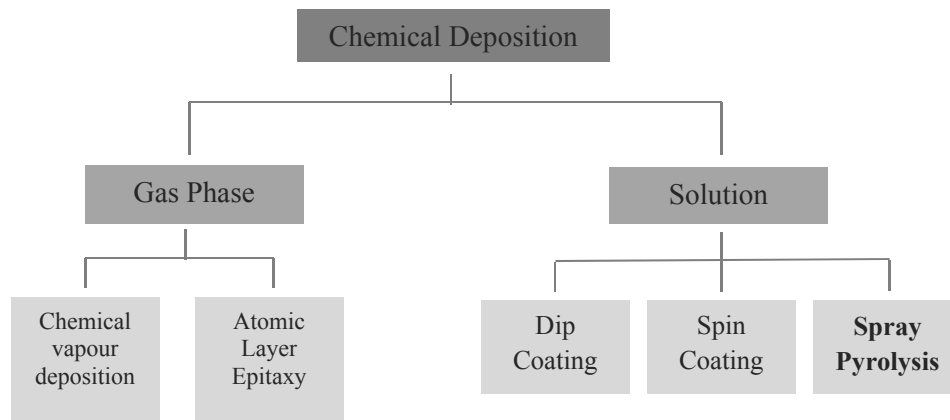


figure 41 - Chemical thin-films deposition techniques⁷

Spray Pyrolysis thin-film deposition technique

According to (Perednis et al: 2005), spray pyrolysis represents a very simple and cost-effective processing method in comparison with the other thin film deposition techniques (especially regarding equipment costs, the fact that this technique may be used in a large size substrate). Spray pyrolysis process consists of a spray nozzle, a precursor solution, a substrate heater and a temperature controller.

The precursor solution is driven by compressed gas to the spray nozzle, which pulverizes the pre-heated substrate. Multilayered films can also be easily prepared using this technique. In this case, there are two or more separate precursor solutions that are separately driven by compressed gas to a specific spray nozzle. When the spray droplets hit the hot substrate surface, the precursor solution suffers pyrolysis or chemical decomposition.

The influence of temperature, precursor solution composition, atomization device in use (which influences the spraying direction and drops dimensions) and substrate cleaning procedure are important variables that we need to take in account in order to achieve a homogenous thin film.

⁷ This figure was built from Perednis et al, 2005 article.

2 - MATERIALS AND METHODS

Glass selection

Commercial soda-lime silica float glass sheets (typical modern window glass) were selected for this experiment in order to easily interconnect the spray-pyrolysis technique to the industrial glass production sequence. Like mentioned above, tin presence is essential in float glass sheets industrial production and this 'tin-surface' can work as reduction agent. Therefore, this process gives rise to the ability to reduce copper ions introduced from an external source.

Samples Preparation

The tin side of the commercial float glass substrates was identified using an UV-Lamp (254 nm). The glass substrates were then cut into specific dimensions. Afterwards there was a cleaning procedure which may be resumed in the following 5 steps: all glass substrates were washed with water and detergent; they were then placed inside a glass container with liquid concentrated nitric acid (HNO_3); afterwards they were placed inside another glass container with distilled water; they were then placed inside a container with a solution of 1:1 distilled water: potassium hydroxide ($\text{H}_2\text{O}:\text{KOH}$); the samples were finally placed inside a glass container with distilled water. After the cleaning procedure, the samples were placed in the spray pyrolysis apparatus.

Spray Pyrolysis Experiment

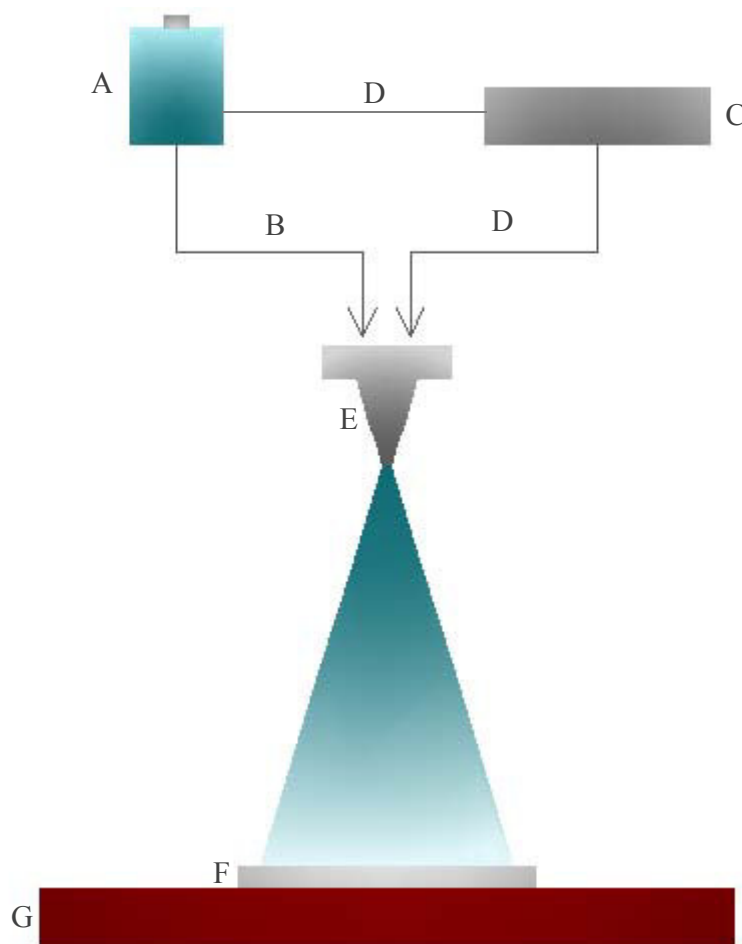


figure 42 - Schematic diagram of spray pyrolysis experiment.

A - precursor solution container; **B** – solution flow; **C** – pressure control system (carrier gas); **D** – carrier gas flow; **E** – spray nozzle; **F** – glass substrate; **G** – heating system

A glass substrate (**F**) is placed on top of the heating system⁸ metal plate (**G**). Kiln paper is placed between the substrate and the heating plate. One container (**A**) is filled with the precursor solution. Container (**A**) is connected to the solution flow (**B**). Solution flow (**B**) allows the precursor solution to flow towards the corresponding moving spray nozzle (**E**). A pressure control system (**C**) is connected to a carrier gas flow (**D**) that pumps the liquid through the tubes. The temperature is measured by the thermocouple type-K (located in the heating system). Temperature is programmed to increase up to a specific value. When it reaches the maximum value, the lid is manually removed and the spray nozzle deposits the precursor solution onto the substrate. In order to avoid thermal shock⁹, the experiments are made with a maximum of three passages (three spray nozzle layers) at each time. After the three spray nozzle layers, we close the lid and wait until the temperature rises up back to the previous value. We repeat the process until we complete all the layers.

Annealing

After the spray pyrolysis, we wait until the temperature drops down to room temperature. Glass samples are then annealed at a specific temperature and duration.

Experiments

We did several experiments from which we selected six (experiments 1, 2, 3, 4, 5 and 6) to illustrate our main line of research.

Precursor Solution Preparation:

20g of Copper (II) Acetate – $\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$ - were diluted into 300ml of distilled water.

Precursor solution concentration: 0,334M.

⁸ The heating system is composed by a steel plate, refractory materials, a lid, a temperature controller and a thermocouple type-k.

⁹ Measurements showed that after three spray nozzle layers, the temperature drops down approximately 30°C.

Table 2 - Experiments 1 to 4

Experiment	Nr of Sprays	Spray Side		Sample dimension (cmxcm)	Spray temp. (°C)	Precursor solution concentration (M)	Annealing process		
		tin side	non tin side				Glass Heating Rate (°C/h)	Annealing temp. (°C)	Annealing time at max. temp. (h)
1A	2	X		1 x 10	200	0,334	360	750	2
1B	4	X							
1C	6	X							
1D	8	X							
1E	10	X							
1F	12	X							
1G	14	X							
1H	16	X							
2A	20	X		10x10	200	0,334	360	750	2
2B	40	X							
3A	40		X	5 x 10	450	0,334	480	650	1
3B	40	X							
4A	10		X	10 x 10	600	0,334	480	650	2
4B	10	X				Note: In this experiments, we used a kiln paper that had already been used before in other spray pyrolysis experiments (it had residues of the precursor solution).			

Experiments 5 and 6

We would like to include two extra experiments in this chapter, which are not related to the spray pyrolysis technique. During our study, we realized that it was also possible to achieve a red copper colour by a very simple process – placing the glass substrate tin side in contact with the kiln paper contaminated with copper acetate at 600°C.

Experiment 5 - In order to replicate this process, we embedded the kiln paper with the aqueous precursor solution of copper (II) acetate (0,334M) for 5 minutes and then placed the tin side glass plate in contact with the kiln paper. The annealing was done at 600°C for 1h (glass heating rate 480°C/h).

Experiment 6 - The aqueous precursor solution of copper (II) acetate (0,334M) was mixed with small amount of *arabic-gum* and then painted in the tin side of the glass plate. The sample was also annealed at 600°C for 2h (glass heating rate 480°C/h).

3 - RESULTS AND DISCUSSION

Theoretical thickness of one layer

The theoretical film thickness of one layer is going to be calculated on the basis of a 100% deposition:

Precursor solution: 20 g of copper (II) acetate – $\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$ + 300 ml of H_2O

H_2O mass: 300 g

Copper (II) Acetate [$\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$] mass: 20 g

Total precursor solution mass: (300 g + 20 g) = 320 g

% Copper (II) acetate/precursor solution: $[(20 \text{ g} \times 100\%) / 320 \text{ g}] = 6,25 \%$

M [$\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$] = 199,7 g/mol

M [CuO] = 79,5 g/mol

% CuO /Copper (II) Acetate = $[(79,5 \text{ g/mol}) / (199,7 \text{ g/mol})] \times 100 = 39,8\%$

Deposited precursor solution (mass/layer) = 0,65 g/layer

Deposited copper (II) acetate (mass/layer) = $6,25\% \times 0,65 \text{ g} = 0,041 \text{ g/layer}$

Deposited copper oxide (mass/layer) = $(0,041 \text{ g} \times 39,8\%) = 0,016 \text{ g/layer}$

CuO density = 6,3 g/cm³

Deposited copper oxide (volume/layer) = $0,016 \text{ g} / 6,3 \text{ g} = 0,0025 \text{ cm}^3$

Spraying Area = (20 cm x 30 cm) = 600 cm²

Thickness of one layer = $(0,0025 \text{ cm}^3 / 600 \text{ cm}^2) = 4,17 \times 10^{-8} \text{ m} = \mathbf{41,7 \text{ nm}}$

Experiment 1

It was pretended to achieve a ruby glass colouration due to the ionic dissolution of the colouring agent into the glass substrate and a reduction of copper due to the presence of tin in the glass substrates. However, the ruby glass colour was not achieved in this experiment.

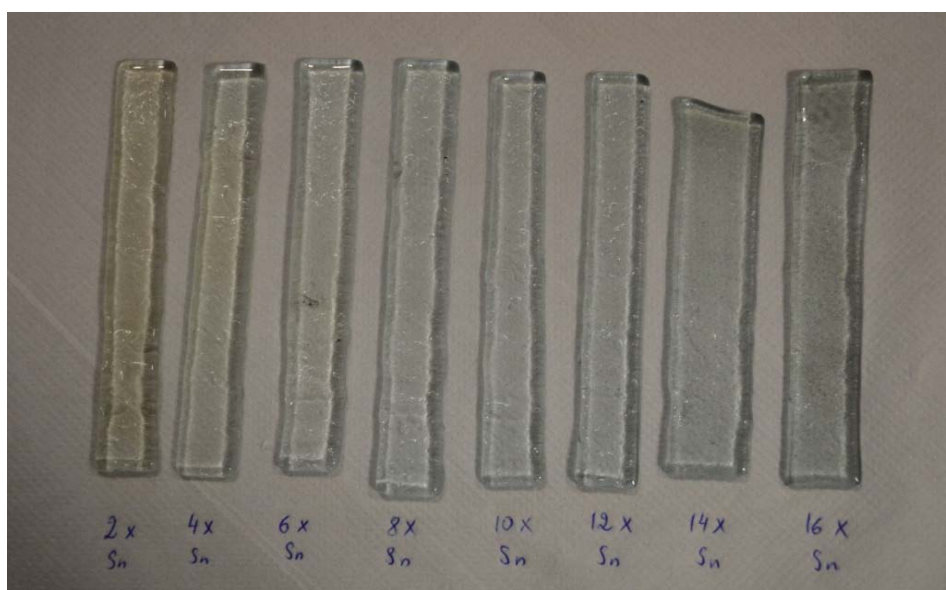


figure 43 - Samples 1A to 1H after annealing (annealing temperature 750°C)

All the samples show a grey colour that darkens as the number of sprays increase after the annealing at 750°C and there is no visible red copper colour formation (figure 43). The visible colour is grey (different shades of gray which darken as the number of sprays increase).

Spray pyrolysis was made using only 200 °C. Therefore, we infer that the spray pyrolysis temperature was not enough for the copper diffusion into the glass substrate or that the number of sprays (maximum 16) were not enough to obtain the copper deposition .

Experiment 2

It was also pretended to obtain a ruby glass colouration due to the reduction of copper and ionic dissolution of the colouring agent into the glass substrate. However, samples 2A and 2B also show a grey colour that darkens as the number of sprays increase (20 sprays in sample 2A and 40 sprays in sample 2B) and there is also no visible red copper colour formation either during the spray or after the annealing at 750°C.

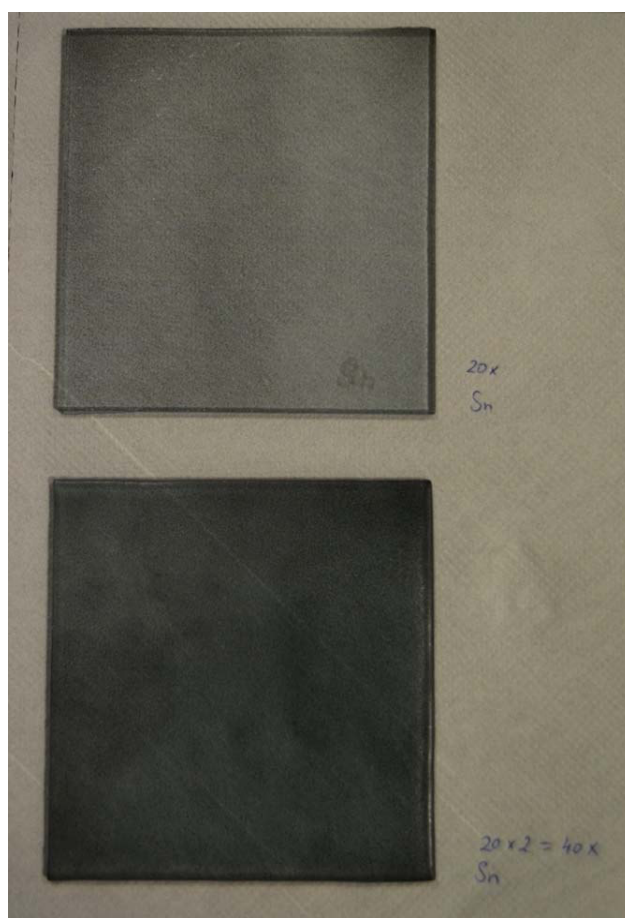


figure 44 - Samples 2A and 2B after annealing (annealing temperature 750°C)

The visible colour is grey and the colour also darkens as the number of sprays increase. Once more the spray pyrolysis was also made using only 200°C. As mentioned in experiment 1, we also infer that the spray pyrolysis temperature was not enough for the copper diffusion into the glass substrate and not due the low number of sprays made in that glass samples. *UV-VIS spectroscopy* was performed in samples 2A and 2B. The results are displayed in the following spectra:

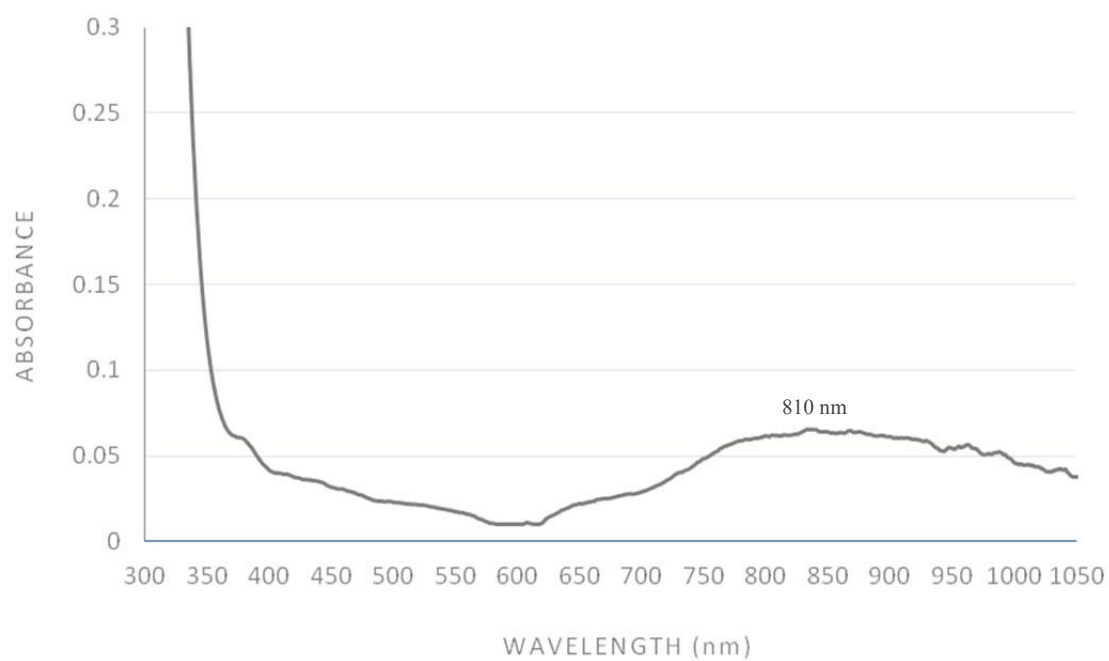


figure 45- Absorption Spectrum of sample 2A

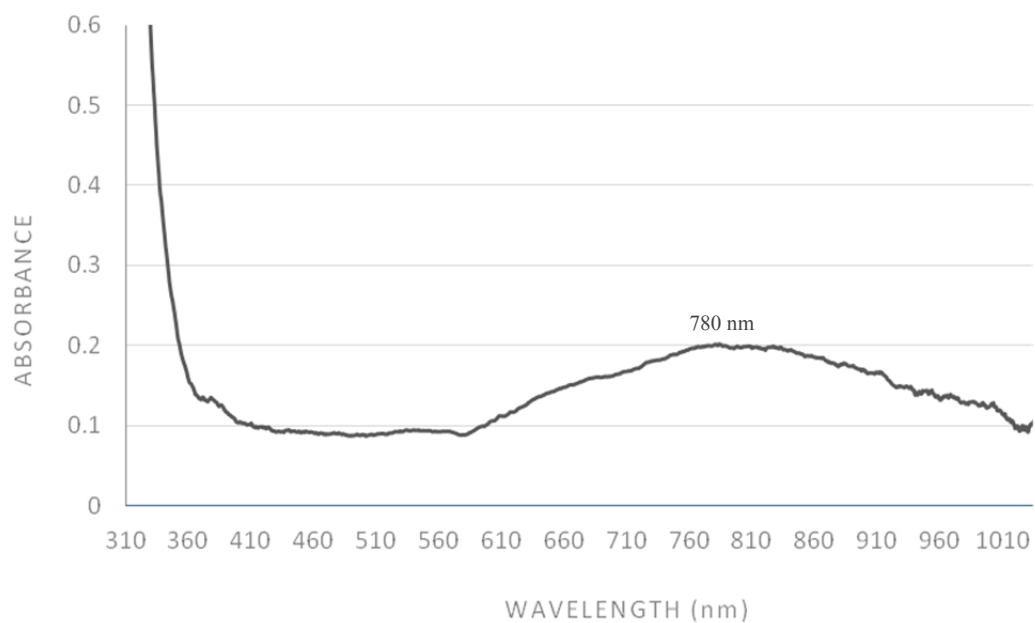


figure 46 - Absorption Spectrum of sample 2B

The absorption spectra of samples 2A and 2B show a band with a maximum peak around 810 nm and 780 nm, respectively. According to Navarro 1991, these are typical spectra of the colouring agent Cu^{2+} , which confirms that there was no copper reduction. Pyrolysis temperature was only 200 °C and it was not enough for the ionic diffusion of the colouring agent, and only a very small amount of Cu^{2+} is deposited in the glass surface, as observed in the absorption spectra. Therefore, there was no reduction and formation of Cu^0 colloidal particles.

Experiment 3

Samples 3A and 3B were both sprayed 40 times at 450°C. After being sprayed with the copper acetate solution, both samples did not present any red colour. However after annealing the samples at 650°C, sample 3A (which was sprayed in the non-tin side) did not show any colour formation, but sample 3B (which was sprayed in the tin side) showed a homogenous red copper hue. Therefore, on the tin side of sample 3B, we were able to achieve the nucleation of Cu^0 nanoparticles.



figure 47 - Samples 3A and 3B after annealing (annealing temperature 650°C). Sample 3A was sprayed in the non-tin side. Sample 3B was sprayed in the tin side.

Sample 3A was sprayed in the non-tin side and there was no nucleation of Cu^0 particles. Therefore, we verify that temperature and also a reducing agent (in this case tin) play an important role for the nucleation of copper Cu^0 nanoparticles. Further studies should be done in order to understand the exact importance of tin role in the reduction and/or nucleation of copper nanoparticles.

UV-VIS spectroscopy was performed in sample 3B in order to confirm the presence of Cu^0 copper nanoparticles. The results are displayed in the following absorption spectrum:

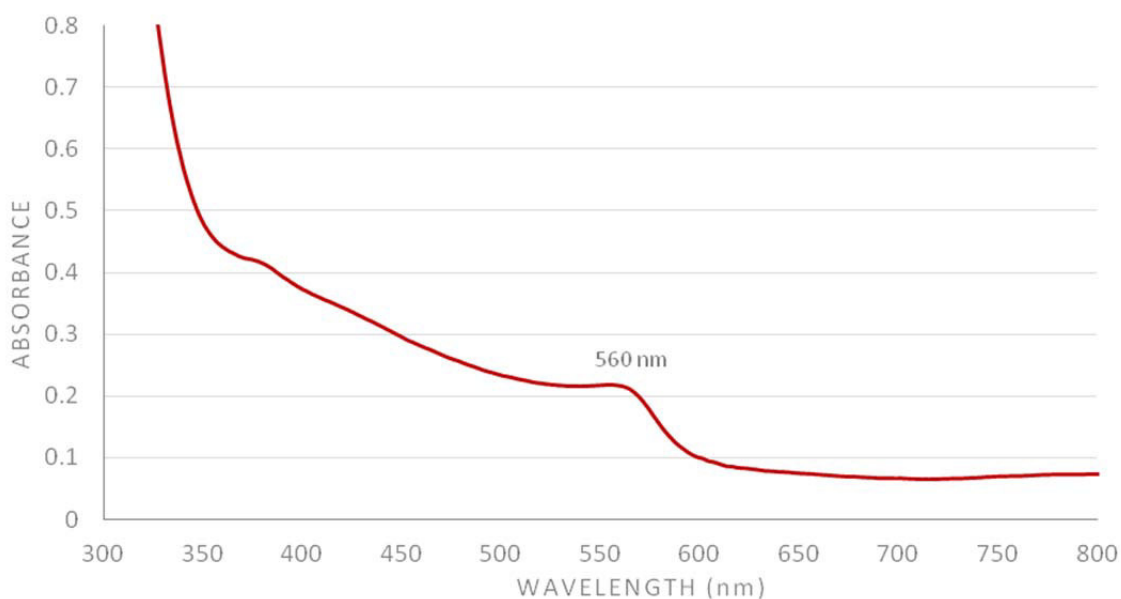
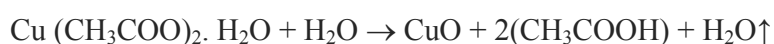


figure 48 - Absorption Spectrum – sample 3B

Sample 3B absorption spectra shows a maximum band at $\lambda = 560$ nm, figure 48. This is a typical ruby copper absorption spectra (Navarro 1991). It is recalled that the red colour only appeared after annealing. There was formation of Cu^0 copper colloidal particles or nanoparticles during annealing. According to Navarro 1991, copper ruby glass chromospheres are created due to the nucleation of nanoparticles or colloidal aggregates with a diameter that varies between 20 and 50 nm and the nanoparticles dimensions depend on the annealing temperature.

One possible chemical reaction that may have occurred during the pyrolysis is represented below:



Afterwards, the copper is reduced by tin that exists in the float glass.

Experiment 4

Samples 4A and 4B were both sprayed 10 times at 600°C. Sample 4A was sprayed in the non-tin side and, as expected, it showed no colour formation in this side of the substrate. However, the tin side (the one that was in contact with the kiln paper) showed a copper red colour.



figure 49 - Samples 4A and 4B after annealing (annealing temperature 650°C). Sample 4A was sprayed in the non-tin side. Sample 4B was sprayed in the tin side.

The kiln paper had already been used before in other experiments and it was contaminated by the precursor solution. In this case, colloidal particles were not created by spray-pyrolysis, but by ionic dissolution of copper components (comprised in the contaminated kiln paper) into the glass substrate. It is recalled that the red colour strike before annealing and pyrolysis temperature was 600°C, as this temperature is enough for the formation of the

copper nanoparticles. Sample 4B was sprayed in the tin side and it did not show colour formation during the spray pyrolysis and also after annealing. We infer that the red colour did not strike during the pyrolysis due to the small amount of precursor solution (the sample was only sprayed 10 times. In experiment 4A, the samples were sprayed 40 times). In this case, we infer that there was only an insignificant reaction between copper and tin components; therefore the red colour did not strike. The non-tin side of this glass substrate was in contact with the kiln paper and it also did not show any colour formation.

UV-VIS spectroscopy was performed in sample 4A in order to confirm the presence of Cu^0 copper nanoparticles. The results are displayed in the following spectrum:

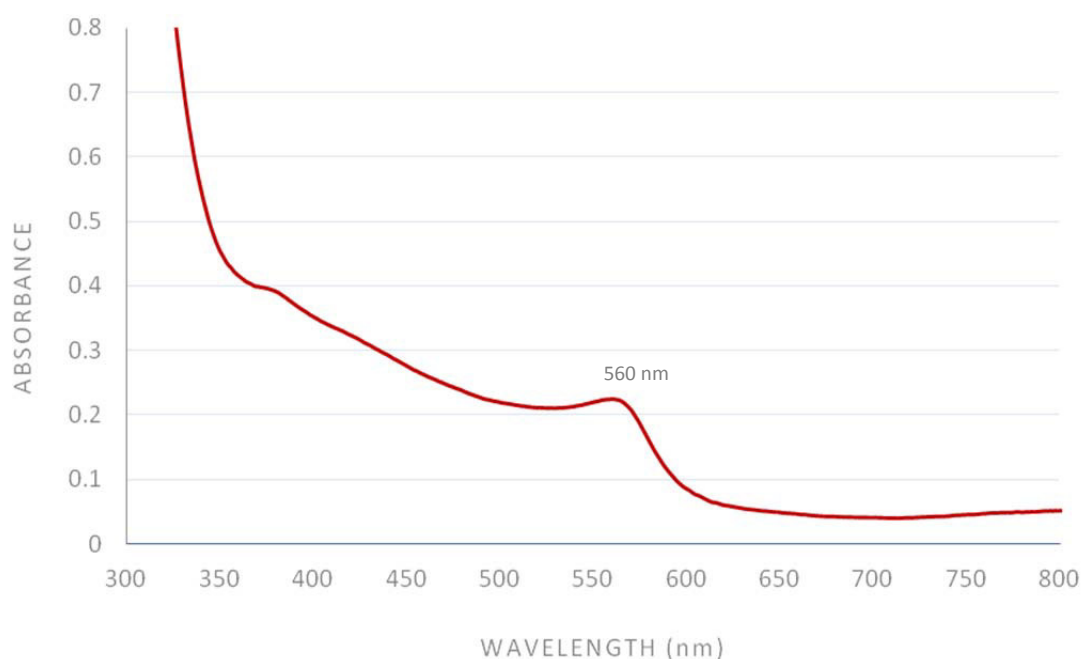


figure 50 - Absorption Spectrum of sample 4A

Sample 4A absorption spectra also shows a band with a maximum at $\lambda=560$ nm, a typical ruby copper absorption spectra (Navarro 1991). Therefore, there was formation of copper colloidal particles in the tin side of the sample (the side that was in contact with the kiln paper). However, these colloidal particles are not created by spray-pyrolysis, but by ionic dissolution of copper components (comprised in the contaminated kiln paper) into the glass substrate.

Experiment 5

Copper red colour was also possible to achieve by placing the tin side glass plate in contact with the kiln paper that was embedded in the precursor solution. However, the colour is not homogeneous (figure 51). Further studies could be done regarding the embedment of the kiln paper, as for example, we only embedded the paper for 5 minutes but if we dip the paper for a long time it might be possible to impregnate the precursor solution into the paper).



figure 51 - Sample 5 after annealing

Experiment 6

Copper red/brownish colour was also possible to achieve by application of the aqueous precursor solution of copper (II) acetate (0,334M) mixed with a small amount of *arabic-gum* in the tin side of the glass plate, figure 52.



figure 52 - Sample 6 after annealing

After the solution application, the glass sample was annealed at 600°C for 2h. After 1h, we opened the kiln and the sample was red; after 2 hours the colour darkened. This may have influenced the colloidal aggregates grow, which darkens the glass colour. According to Navarro 1991, if the colloidal particles diameter grows too much, the glass becomes hazed and even opaque. Further studies should be done in order to understand the temperature influence, the brushstroke thickness and the amount of arabic-gum that is mixed with the precursor solution in order to achieve a homogeneous red copper colour.

4 - CONCLUSIONS

Pyrolysis of copper (II) acetate [$\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$] into glass substrates (soda-lime silica glass plates – float glass) was achieved at a specific temperature (spray pyrolysis at 450°C and annealing at 650°C) and precursor solution concentration (0,334M).

On the tin side of sample 3B, we were able to achieve the nucleation of Cu^0 nanoparticles. Sample 3A was sprayed in the non-tin side and there was no nucleation of Cu^0 particles. In this case, the substrate is colourless; we infer that there was a reduction from Cu^{2+} to Cu^0 . Therefore, tin component plays an important role in copper reduction from Cu^{2+} to Cu^0 and in the nucleation of colloidal particles. Further studies should be done in order to understand the exact importance of tin role in the reduction and/or nucleation of copper nanoparticles.

Furthermore, we confirm that industrial float soda-lime glass sheets can be used in the spray pyrolysis red copper colouring process. The ‘tin-surface’ is produced in the industrial float process. The final float glass contains a tin concentration which gives rise to the ability to reduce copper ions introduced from an external source. This also reduces the cost of red copper spray pyrolysis technique because it can be easily introduced in the float glass production sequence.

Samples 2A and 2B were sprayed in the tin side. However, there was no formation of red copper nanoparticles (see absorption spectra from sample 2A and 2B). The samples show a grey colour and UV-Vis absorption spectroscopy confirms the presence of Cu^{2+} ions. Therefore, we infer that the temperature (200°C) was too low for the ionic dissolution of the colouring agent.

Further studies should be done in order to understand how and where does the ion exchange happen (e.g. what is the depth of the nanoparticles diffusion into the glass substrate?). Also, we need to calculate the exact film thickness (in this experience, it was calculated on the basis of a 100% deposition).

Therefore, other techniques may be used, like X-Ray Fluorescence (XRF) and Rutherford Backscattering Spectrometry (RBS). XRF would allow us to perform an accurate analysis of the substrate multi-elements composition and concentration range (before pyrolysis, after pyrolysis and after annealing). RBS would also allow us to do a quantitative determination of the composition of the glass substrate and depth profiling of individual elements (MAYER 2003).

Copper (II) acetate Spray Pyrolysis is a very simple and cost-effective technique that allows us to colour glass at a temperature of 650°C – below the softening point of glass. Therefore,

it is possible to produce colourless large scale glass plates and afterwards, to colour them with this technique. It is also possible to make art objects and then colour them without changing their original shape.

Copper red colour was also possible to achieve with another process (see samples 5 and 6): ionic dissolution of copper components (comprised in the contaminated kiln paper) into the glass substrate. Other studies should be made in order to replicate this process and achieve a homogeneous red copper colour. This is a very simple and cost effective method for an artist to colour glass with and it can be used in connection with other techniques. It is possible, for example, to create drawings or patterns in the kiln paper with the precursor solution and then place the tin side of the glass substrate in contact with the paper and anneal them together in the kiln (at 600°C - under the softening point). Also, the kiln paper is flexible and it is possible to adapt it to the shape of a three-dimensional glass substrate.

5 - REFERENCES

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Trabalho Científico

Biodeterioration of contemporary glass art by fungi

ABSTRACT

This work presents the first results regarding fungi biodeterioration on contemporary glass used by artists worldwide. The fungi biological attack on contemporary glass art was studied using contemporary glass production methods. The glass production was made according to the chemical composition of Spruce Pine 87 Batch.

Colorless glass samples were inoculated with two fungi, *Penicillium* sp. and *Aspergillus* sp., separately. Half of the samples were inoculated only with fungal spores and the other half were inoculated with fungi and a small portion of culture media in order to simulate the organic matter (dust) that can be deposited in the artworks.

Physical and chemical glass surface alterations were analyzed using Optical Microscopy, μ -Raman and SEM-EDS.

Fungi with culture media produced more damages than fungi without a nutritional source. However, in both cases fungi were able to grow and produce damages on glass. It was also noticed that *Penicillium* sp. produced more hyphae fingerprints, stains and iridescence and less biopitting and crystals than *Aspergillus* sp. Nonetheless, results showed that both fungi produced physical and chemical damages on glass surfaces: iridescence, spots and stains, hyphae fingerprints, biopitting, depletion and deposition of elements and crystals. Therefore, all inoculated fungi were able to biodeteriorate Spruce Pine 87 Batch glass samples.

Keywords: biodeterioration, fungi, *Aspergillus* sp., *Penicillium* sp., sodalime glass, contemporary glass art, Spruce Pine Batch 87.

1 – INTRODUCTION

There are several studies regarding glass biodeterioration by fungi, most of them are related to historical glass (e.g. Carmona et al., 2006; Rodrigues et al., 2014) and there are a few about optical glass (e.g. Bartosik et al., 2010) but none of them studies contemporary glass art. In this work we selected Spruce Pine 87 Batch glass since it is used by many renowned artists around the world on their work of art.

Spruce Pine 87 Batch glass is a contemporary glass related to the Studio Glass Movement. According to Corning Museum of Glass, in 1962, glass scientist Dominick Labino and the artist Harvey K. Littleton introduced artists to the material of glass as an artistic expression medium (Sterbenk and Kritzeck, 2011). Littleton and Labino made available to artists all the technical knowledge to formulate a low temperature melting-point glass (supplied by Labino), a portable furnace and glassblowing techniques. This knowledge kickstarted the American Studio Glass movement, which emphasized glass artist as a designer and maker (Sterbenk and Kritzeck, 2011).

In 1963 Littleton established the first glass program in the USA at the University of Wisconsin and attracted many students like Dale Chihuly and Marvin Lipovsky (*Falconer, 2011*). In 1977 Littleton retired from teaching and moved to Wisconsin, Spruce Pine, where he worked as an independent artist and in 1998 opened the Spruce Pine Batch Company that still uses Dominick Labino formula, a low temperature melting-point soda-lime glass specifically for use by studio glass (artists were no longer dependent on factories to manufacture glass artworks). The Spruce Pine 87 Batch glass was and still is acquired by glass artists all over the world. Therefore, there are many works of art made with this type of glass. Some of these works are located inside Museums, Galleries and other are outdoors. Regardless of their location, they are all subject to the effects of environmental factors (temperature, relative humidity, dust deposition...) and biotic factors, such as bacteria, fungi, microalgae, etc... Therefore, physical, chemical and biological processes are involved in glass corrosion (Aulinas et al., 2008).

The biological corrosion or biodeterioration was defined by (Hueck et al., 1965) as “any undesirable change in the properties of a material caused by the vital activities of living organisms”. Observations regarding biodeterioration assume an interrelationship between microbial growth and favorable climatic and environmental conditions (Drewello and Weissmann, 1997). Aulinas et al. (2008) also indicates that glass deterioration is related to the interaction between organic activity, environmental parameters and interaction between cations forming the glass.

Initial symptoms of glass biodeterioration are etching, pit corrosion and leaching of glass elements (Krumbein et al., 1998). Biodeterioration of glass can be due to lichens, algae, cyanobacteria, bacteria and fungi (Garcia-Valles, 2003). Accordingly to Drewello and Weissman (1997) biophysical mechanisms are often related to lichens and fungi and biochemical mechanisms are related to fungi and bacteria. These authors also claim that fungi play an important role on glass biodeterioration. In fact, there are several studies on biodeterioration of glass by fungi reporting that these microorganisms are responsible for irreversible damages on glass (e.g, Kerner-Gang and Theden, 1964; Drewello and Weissmann, 1997; Gorbushina and Palinska 1999; Carmona et al., 2006; Rodrigues et al., 2014). Fungi can be the dominant species colonizing the glass surface, and their metabolites are responsible for the irreplaceable changes and degradation of the structure and composition of this inorganic material (Watkins et al., 2003). It is also known that fungi have the ability to precipitate secondary mycogenic minerals within rock substrata (Burford et al, 2003), this implicates that they may be able to do the same in glass.

Fungi of the following genera are referred to as capable of causing glass biodeterioration: *Aspergillus*, *Cladosporium*, *Trichoderma*, *Penicillium*, *Chaetomium*, *Aureobasidium*, *Eurotium*, *Phoma*, *Scopulariopsis* and *Rhizopus*.

The main objective of this work is to study the biodeterioration of Spruce Pine Batch 87 glass by fungi, and to determine how to prevent that from happening. In order to achieve this goal it was necessary to:

- Do a literature review regarding fungi found on glass;
- Select two fungi genera to be used in this colonization experiment;
- Produce Spruce Pine Batch 87 glass (according to the composition provided by Corning Museum of Glass);
- Colonize the selected fungi on the sterilized Spruce Pine Batch 87 glass samples;
- Use different analytical techniques in order to study the biodeterioration of the inoculated glass surfaces after 4 and 6 months of incubation.

2 - MATERIALS AND METHODS

2.1 Fungi selection criteria

The fungi selection for the glass biodeterioration experiment followed the criteria mentioned below:

- the most common fungi found on different types of glass (glasses with different composition);

- fungi that were found more often as agents of glass biodeterioration.

2.2 Spruce Pine Batch 87 glass production

Spruce Pine Batch 87 glass composition was personally provided to this investigation team by a member of Corning Museum of Glass. This glass is a sodalime glass.

Glass samples were manufactured in Vicarte Research UNIT based on the chemical composition of Spruce Pine Batch 87. The glass components were mixed using raw laboratorial materials and afterwards melt in the kiln (Melting Temperature – 1300 °C) (Termolab – Fornos Eléctricos Lda).

In order to manufacture Spruce Pine Batch 87 glass, the following oxides were used: SiO₂, Al₂O₃, MgO, Sb₂O₃, Na₃AlF₆, Er₂O₃ and Fe₂O₃ (Table 2).

Table 3 – Oxides (w/w) used to produce the Spruce Pine Batch 87 glass

Oxides	SiO ₂	Al ₂ O ₃	Na ₂ O	K ₂ O	Li ₂ O	CaO	MgO	BaO	ZnO	Sb ₂ O ₃	Na ₃ AlF ₆	Er ₂ O ₃	Fe ₂ O ₃
(w/w)	71,9	1,79	14,89	0,40	1,00	7,90	0,20	0,50	1,00	0,20	0,10	0,09	0,02

Carbonates (Na₂CO₃, K₂CO₃, Li₂CO₃, CaCO₃, BaCO₃, ZnCO₃) were also used as raw material and transformed afterwards into oxides due to temperature:



The glass obtained was hand blown using traditional tools and techniques. The resulting roundels (circular glass plates) were annealed at 500 °C for 4h and then slow cooled (for approximately one day). The roundels were then cut into 30 square glass samples (1cmx1cm).

2.3 Glass biodeterioration experiment

Two glass Petri dishes (150 mm diameter) with distilled water at the bottom and a stainless steel net inside, were used in this experiment (fig.53). Glass samples were placed on top of

the stainless steel net avoiding the contact between the samples and the water. The distilled water was used in order to maintain a high relative humidity, which promotes fungi growth. Each stainless steel net was split into three sections (fig. 53). The two selected fungi were inoculated in separated glass Petri dishes. Fifteen glass samples were placed in each Petri dish on top of a stainless steel net and then sterilized in an autoclave at 121°C for 1h.

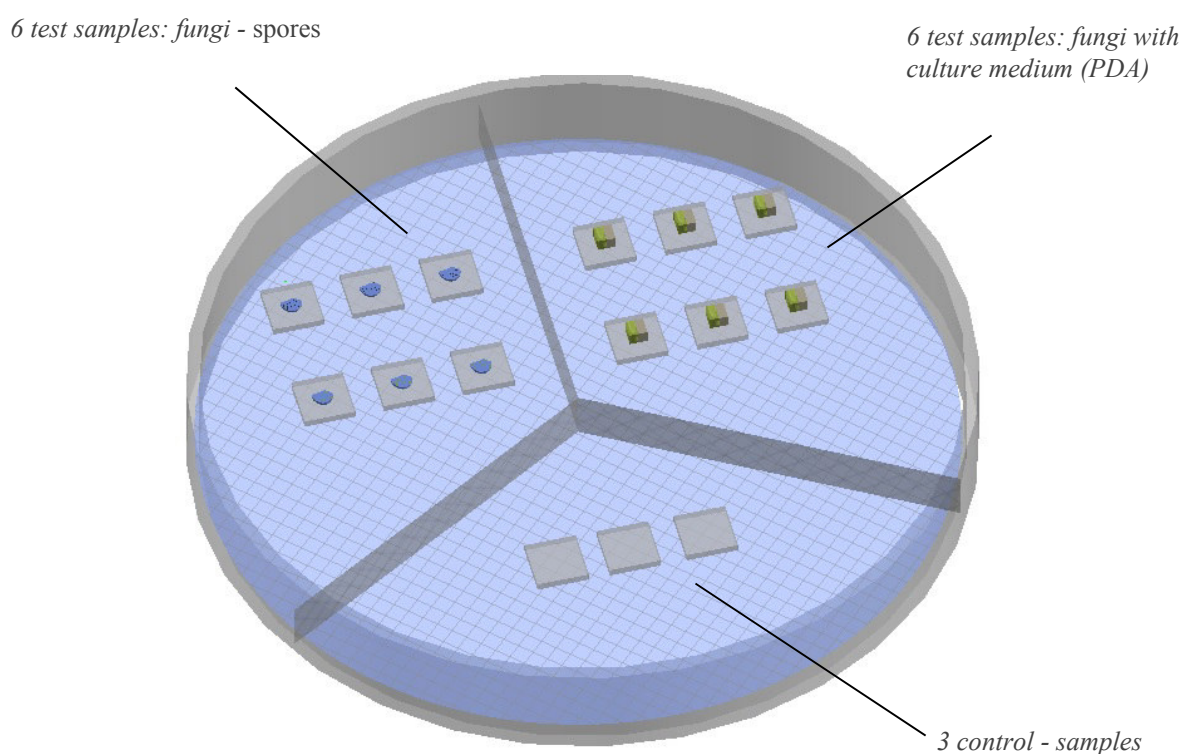


figure 53 – Glass Petri dish with glass samples (showing control samples, samples inoculated with fungi spores and samples inoculated with PDA)

12 of the 15 glass samples were inoculated with one genera of the selected fungi. Six of the 12 glass samples were inoculated with a small bit of culture medium, Potato Dextrose Agar (PDA). This medium was used in order to simulate the organic and inorganic matter that can be deposited on the glass artworks (fig 54a). The other six glass samples were inoculated with spores (in a 0.05% tween solution) (fig. 54b). The Tween solution was used to guarantee that all the samples were inoculated with the same spores concentration. Finally, 3 clean glass samples were placed under the same conditions for control purposes (fig. 53). The same procedure was made for both selected fungi.

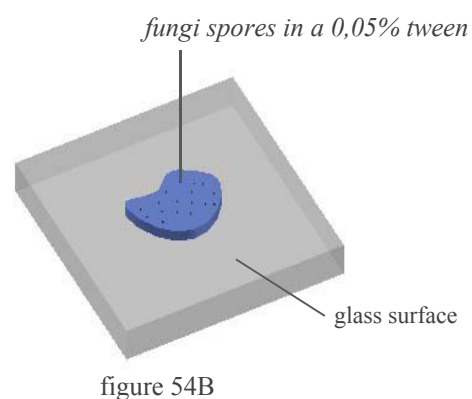
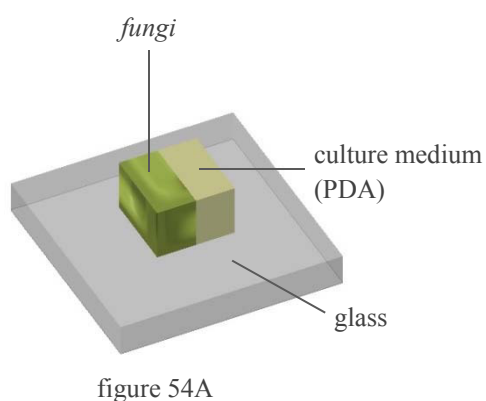


figure 54 – A (Inoculated samples with fungi and PDA) and B (Inoculated samples with fungi spores in a 0.05% tween solution)

All the Petri dishes were then placed inside a translucent acrylic box with water at the bottom to ensure high relative humidity conditions (75-80% RH) under controlled temperature (22-23°C). The samples were incubated during 6 months but after 4 months, 3 inoculated samples were taken from the petri dishes and analyzed. Fig. 55 shows the experimental design used for one fungi; the same procedure was made for the other fungi.

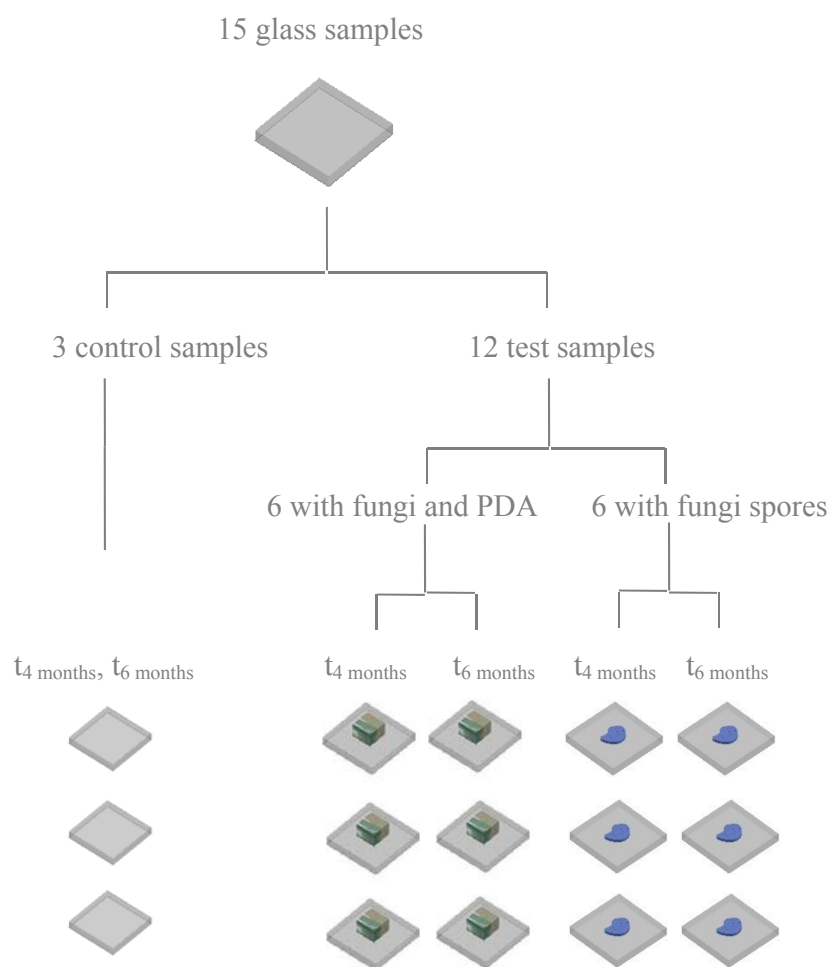


figure 55 - Experimental design - glass biodeterioration experiment

2.4 Post-experiment analyses of glass surface alterations

A set of techniques was used to characterize the morphological and chemical alteration of the glass surfaces during the biodeterioration experiment. The analyses were performed on the glass samples before and after a cleaning procedure (cleaning consisted of a mechanical biofilm removal with a cotton swab embedded in a 1:1 water ethanol solution).

2.4.1 Optical microscopy

The microscopic documentation was carried out using a light microscope (Axioplan 2, Zeiss) with digital camera (Nikon DMX) on samples with biofilm and after the cleaning procedure.

2.4.2 Scanning electron microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS)

Samples were also analysed by Scanning Electron Microscope – SEM-EDS (Scanning Electron Microscope with image processing, quantitative analysis and elemental chemical analysis by EDS) at CENIMAT|I3N, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa (Monte da Caparica, Portugal). Glass samples were observed after the cleaning procedure. SEM-EDS complemented the Optical Microscopy observations and allowed us to access physical alterations on the glass surface and chemical elemental analysis.

2.4.3 Raman microspectroscopy

Raman microspectroscopy (μ -Raman) was carried out using Raman Horiba Jobin Yvon - Model LabRaman 300 at the Conservation and Restoration Department, Faculty of Science and Technology, New University of Lisbon. Raman analysis were performed on the glass surfaces, allowing for the identification of the corrosion and biocorrosion products (Rodrigues, 2014). In order to obtain the spectra, the laser beam had a wavelength of 532nm and it was focused with a 50x Olympus lens. The analysis were made without filter and with the following parameters: 15 cycles of 30 seconds and a wavenumber range between 100 and 1500 cm^{-1} .

In order to do the spectra curve fitting, the baseline was subtracted using Labspec (DILOR) software.

3. RESULTS AND DISCUSSION

3.1 Literature review regarding fungi on glass

An extensive literature review, from 1943 to 2014, was made in order to determine the most common fungi genera found by previous studies on glass. The results from the literature research are presented in Table 4. This table discriminates between the fungi that were reported as biodeterioration agents (IB – Identified as Biodeterioration agents) and those that were only identified on glass (I- Identified) but there is no information regarding their potential for glass biodeterioration. Table 4 also shows information about the types of glass where fungi were found and respective bibliographic references.

Table 4 - Fungi found on glass, types of glass and bibliographic references

IB –fungi found on glass as a biodeterioration agent; I – fungi found on glass

Fungi	Type of Glass	Information		Bibliographic Reference
		IB	I	
<i>Acremonium</i> sp.	Potash-lime-silicate	X		Gorbushina and Palinska, 1999
<i>Alternaria tenuissima</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>A. tenuissima</i>	XVII Century German Potash Glass Panel		X	Rodrigues et al., 2014
<i>Aspergillus</i> sp.	Potash-lime-silicate	X		Gorbushina and Palinska, 1999
<i>A. sp.</i>	Optical Glass – SK (dense barium crown)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – SF (extra dense flint)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – F (dense flint)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – KF (crown flint)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – BaK (medium barium crown)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – SSK (dense barium crown)	X		Ohtsuki, 1943
<i>A. sp.</i>	Optical Glass – BK (borosilicate)		X	Ohtsuki, 1943
<i>A. amstelodami</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>A. amstelodami</i>	Optical Glass – F (dense flint)	X		Kerner-Gang, 1968
<i>A. fischeri</i>	Optical Glass –SF (extra dense flint)	X		Kerner-Gang, 1968
<i>A. fumigatus</i>	Potash-lime-silicate		X	Carmona et al., 2006
<i>A. niger</i>	Optical Glass – BK7 (borosilicate glass)		X	Bartosik et al., 2010
<i>A. niger</i>	Optical Glass – BaK 4 (medium barium crown)	X		Bartosik et al., 2010
<i>A. niger</i>	Optical Glass – SF 2 (extra dense flint)	X		Bartosik et al., 2010
<i>A. niger</i>	Optical Glass – F 2 (dense flint)	X		Bartosik et al., 2010
<i>A. niger</i>	Optical Glass – F (dense flint)	X		Kerner-Gang, 1968
<i>A. niger</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>A. niger</i>	Potash-lime-silicate	X		Drewello et al., 2000
<i>A. niger</i>	Sodalime		X	Gallien et al., 2001
<i>A. penicilloides</i>	Potash-lime-silicate		X	Carmona et al., 2006
<i>A. restrictus</i>	Potash-lime-silicate		X	Carmona et al., 2006
<i>A. tamarii</i>	Potash-lime-silicate	X		Carmona et al., 2006
<i>A. versicolor</i>	Optical Glass – SK (dense barium crown)		X	Kerner-Gang and Theden, 1964
<i>A. versicolor</i>	Optical Glass – Glass Plate		X	Kerner-Gang and Theden, 1964
<i>A. versicolor</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>A. versicolor</i>	Optical Glass – T-Belag (titanium coating)	X		Kerner-Gang, 1968
<i>A. viticola</i>	Optical Glass – F2 (dense flint)		X	Kerner-Gang and Theden, 1964
<i>Chaetomium</i>	XV Century Swiss Mixed-Alkali Glass		X	Rodrigues et al., 2014

<i>coarctatum</i>	Panel			
<i>C. globosum</i>	Optical Glass – F2 (dense flint)		X	Kerner-Gang and Theden, 1964
<i>C. globosum</i>	Optical Glass – K5 (hard crown)		X	Kerner-Gang and Theden, 1964
<i>Cladosporium</i> sp.	Sodalime		X	Gallien et al., 2001
<i>C. sp.</i>	XV Century Swiss Mixed-Alkali Glass Panel	X		Rodrigues et al., 2014
<i>C. sp.</i>	XVII Century German Potash Glass Panel	X		Rodrigues et al., 2014
<i>C. langeronii</i>	XV Century Swiss Mixed-Alkali Glass Panel		X	Rodrigues et al., 2014
<i>C. sphaerospermum</i>	XV Century Swiss Mixed-Alkali Glass Panel		X	Rodrigues et al., 2014
<i>C. sphaerospermum</i>	XVII Century German Potash Glass Panel		X	Rodrigues et al., 2014
<i>Dactylium fusarioides</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>Didymella phacae</i>	XVII Century German Potash Glass Panel		X	Rodrigues et al., 2014
<i>Eurotium</i> sp.	Optical Glass – SK (dense barium crown)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – SF (extra dense flint)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – F (dense flint)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – KF (crown flint)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – BaK (medium barium crown)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – SSK (dense barium crown)	X		Ohtsuki, 1943
<i>E. sp.</i>	Optical Glass – BK (borosilicate)		X	Ohtsuki, 1943
<i>E. tonophilum</i>	Optical Glass – SK6 (dense barium crown)		X	Kerner-Gang and Gerda, 1964
<i>Paecilomyces variotii</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>P. variotii</i>	Optical Glass – SF4 (extra dense flint)		X	Kerner-Gang and Gerda, 1964
<i>P. variotii</i>	Optical Glass – BK7 (borosilicate)		X	Kerner-Gang and Gerda, 1964
<i>Penicillium</i> sp.	Optical Glass – Glass Plate		X	Kerner-Gang and Gerda, 1964
<i>P. sp.</i>	XV Century Swiss Mixed-Alkali Glass Panel	X		Rodrigues et al., 2014
<i>P. sp.</i>	XVII Century German Potash Glass Panel	X		Rodrigues et al., 2014
<i>P. aurantiogriseum</i>	Potassium lime silicate	X		Drewello et al., 2000
<i>P. brevicompactum</i>	XV Century Swiss Mixed-Alkali Glass Panel		X	Rodrigues et al., 2014
<i>P. citreonigrum</i>	XV Century Swiss Mixed-Alkali Glass Panel		X	Rodrigues et al., 2014
<i>P. citreonigrum</i>	XVII Century German Potash Glass Panel		X	Rodrigues et al., 2014
<i>P. citrinum</i>	Optical Glass – F (dense flint)	X		Kerner-Gang, 1968
<i>P. funiculosus</i>	Optical Glass – F (dense flint)	X		Kerner-Gang, 1968
<i>P. funiculosus</i>	Optical Glass – SF (extra dense flint)	X		Kerner-Gang, 1968
<i>P. funiculosus</i>	Optical Glass – F2 (dense flint)		X	Kerner-Gang and Theden, 1964
<i>P. funiculosus</i>	Optical Glass – SF4 (extra dense flint)		X	Kerner-Gang and Theden, 1964
<i>P. funiculosus</i>	Optical Glass – SK 16 (dense barium crown)		X	Kerner-Gang and Theden, 1964

<i>P. notatum</i>	Borosilicate	X		Callot et al., 1987
<i>P. notatum</i>	Optical Glass – SK (dense barium crown)	X		Kerner-Gang, 1968
<i>P. notatum</i>	Optical Glass – F2 (dense flint)		X	Kerner-Gang and Theden, 1964
<i>P. notatum</i>	Sodalime	X		Callot et al., 1987
<i>P. roseopurpureum</i>	XV Century Swiss Mixed-Alkali Glass Panel		X	Rodrigues et al., 2014
<i>Sistotrema</i> sp.	XVII Century German Potash Glass Panel		X	Rodrigues et al., 2014
<i>Taeniolina deightonii</i>	Reproduction of medieval frit		X	Kaiser et al., 1996
<i>Trichoderma viride</i>	Optical Glass – K (crown glass)	X		Kerner-Gang, 1968
<i>Trimmatostoma</i> sp.	Potassium lime silicate	X		Gorbushina and Palinska, 1999

A total of 14 different genera of fungi and 34 species were identified on distinct types of glass by several authors (table 4). Optical glass was studied only by 4 authors (Ohtsuki, 1943; Bartosik et al., 2010; Kerner-Gang, 1968; Kerner-Gang and Theden, 1964) and they identified a total of 16 genera. However, most of the studies deal with historical glass (e.g. Gorbushina and Palinska, 1999; Carmona et al., 2006; Rodrigues et al., 2014) (Table 1). It is also important to notice that older studies (e.g. Ohtsuki, 1943; Kerner-Gang, 1968; Kerner-Gang and Theden, 1964) only use the culture methods for the optical microscope fungi identification and that more recent studies also use molecular biology techniques (e.g. Carmona et al., 2006; Rodrigues et al., 2014)

Based on the literature review presented on table4, the fungi genera found on glass as biodeterioration agents and the number of study cases reported for each genera were calculated and can be seen on fig. 56.

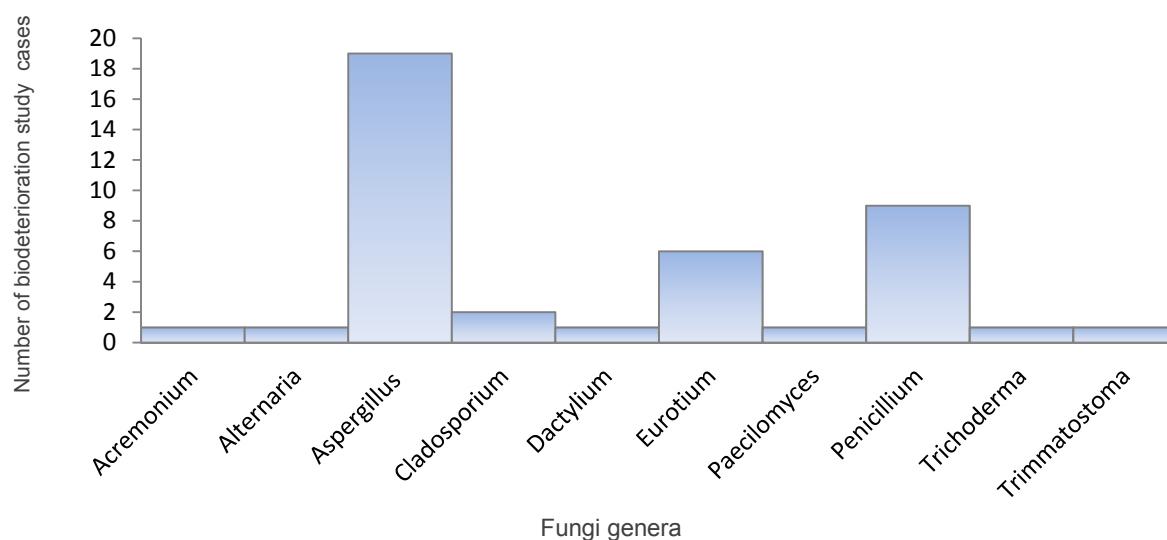


figure 56 - Fungi genera found on glass as biodeterioration agents and the number of study cases reported for each genera

The most common fungi genera reported as glass biodeterioration agents are: *Aspergillus* sp. and *Penicillium* sp. (Table 4 and fig. 56).

3.2 Fungi selection for the biodeterioration experiment

Spruce Pine Batch 87 glass is a sodalime glass. The biodeterioration of this type of glass was only studied by two authors: Gallien et al., 2001 and Callot et al., 1987 (Table 4). Gallien et al., (2001) selected *Aspergillus niger* and *Cladosporium* sp for the biodeterioration experiments. In the first days of leaching, fungi development conducted to acid pH (from 4.5 to 1.7 for *Aspergillus niger*) and fungi mycelium was strongly anchored on the glass surface. In 1987 Callot et al., used *Penicillium notatum* for glass biodeterioration experiments. Results showed that sodalime glass had a friable reaction layer at a few isolated spots and hyphae fingerprints.

Aspergillus genera was found on 11 different types of glass. 10 species of this genera were reported, the most common being *Aspergillus niger*. *Penicillium* genera was identified on 9 different types of glass. 8 *Penicillium* species were found and *Penicillium funiculosum* specie is the most common one since it appears on 5 distinct types of glass (Table 4). Both *Aspergillus* sp. and *Penicillium* sp. are air born fungi and they are able to colonize distinct types of glass. Moreover, accordingly to Kerner-Gang, et al. (1968) *Aspergillus* can cause glass biodeterioration in 5 days, while *Penicillium* biodeteriorates glass after 40 days of incubation (Drewello et al. 2000).

Aspergillus sp. was found biodeteriorating very different type of glass: optical glass (Ohtsuki, 1962; Theden and Kerner-Gang, 1964; Kerner-Gang, 1968; Bartosik et al., 2010) and potassium lime silicate (Drewello et al., 2000; Carmona et al., 2006). Kerner-Gang, et al. (1968) developed their studies on distinct optical glass types. Pits in the optical glass were caused by *Aspergillus versicolor* conidia after 5 days. It is interesting to notice that the destructive process was slower when *Penicillium funiculosum*, *Alternaria tenuis* and *Aspergillus fischeri* fungi were also present. On the other hand Bartosik et al. (2010) got to the conclusion that the lubricant 4CKP (used in the production of optical instruments) could initiate the growth of conidia of *Aspergillus niger* since it is assimilable by the fungi and in consequence can cause glass biodeterioration. Carmona et al., 2006 studied stained glass windows samples from the 15th century. The major components detected in the glass samples belong to the fungal genera *Aspergillus* with 99% similarity with *A. fumigatus*, *A. restrictus*, *A. tamaraii* and *A. penicilloides*.

Penicillium sp. was detected regarding the following types of glass deterioration: Potassium lime silicate (Drewello et al., 2000;), Borosilicate (Callot et al., 1987), sodalime (Callot et

al., 1987), optical glass (Kerner Gang and Theden, 1964), XVII Century German Potash Glass (Rodrigues et al., 2014) and XV Century Swiss Mixed-Alkali Glass Panel (Rodrigues et al., 2014).

Penicillium aurantiogriseum was incubated under high relative humidity (95% RH) for 40 days and after that there were still remains of biominerals (calcite, kaliginite and whewellite). Their full removal required a higher energy density ($> 2\text{-}2.5\text{ J/cm}^2$) and this is already the energy threshold for the damaging of the glass (Drewello et al., 2000).

Callot et al. (1987) also studied the biocorrosive action of *Penicillium notatum* in borosilicate glass; the main effects were microfractures and a thin but opaque reaction layer. Rodrigues et al. (2014) used *Penicillium* sp. and *Cladosporium* sp., on their glass biodeterioration experiment. Results showed that after 2.5 months of incubation there was a formation of large quantities of crystalline substances and some prints which were attributed to the presence of both fungi. However, the biodeterioration effect of *Penicillium* sp. alone could not be separated from the biodeterioration produced by *Cladosporium* sp. Therefore, in the present work fungi genera are inoculated in distinct glass samples.

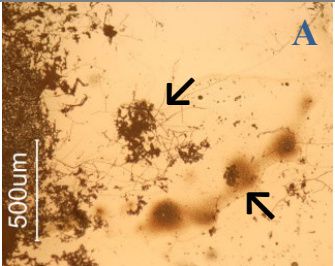
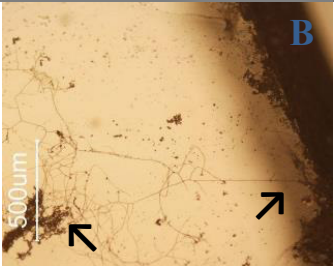


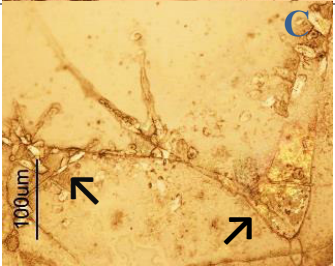
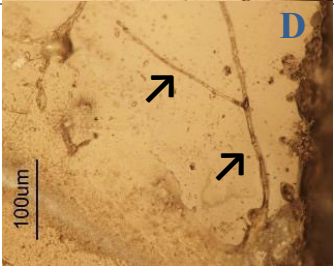
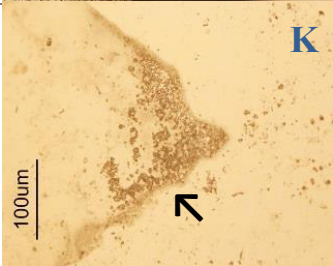
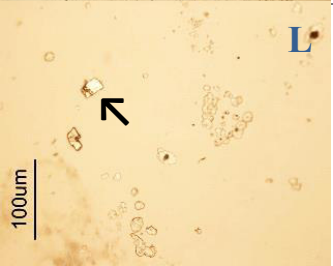
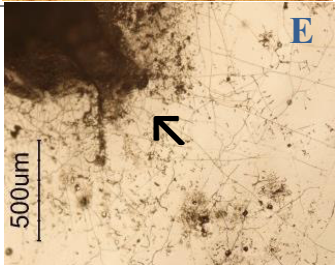

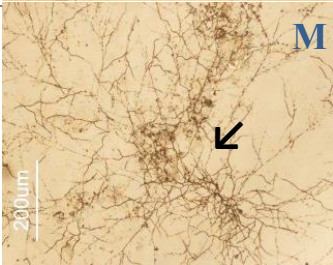
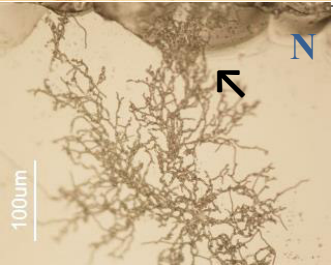
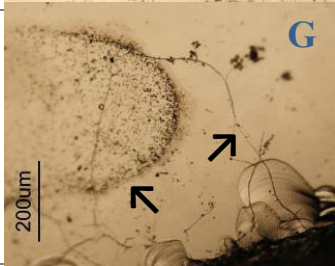
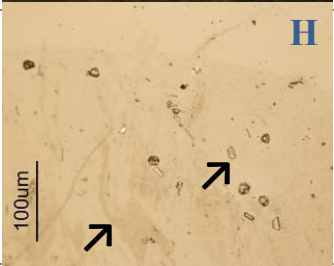

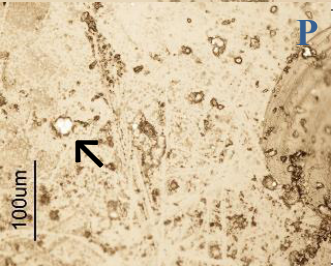
All these information led us to select *Aspergillus* sp. and *Penicillium* sp. for the biodeterioration experiment.

3.3 Optical Microscope results

Optical Microscopy allowed to the observation of the mycelium growth, chromatic alterations and corrosion patterns on the glass surface (for example, hyphae fingerprints, biopitting and crystal formation).

Table 5 presents the optical microscopy observations made on glass samples inoculated with *Penicillium* sp. after 4 and 6 months of incubation (before and after the cleaning procedure). The results show the fungi inoculated samples with PDA and the ones with spores. See figures 57A and 57B that present the control samples, in order to compare with the results of the inoculated samples.

Table 5 - Optical microscopy observations of the surface glass samples 4 and 6 months after the incubation with *Penicillium* sp.

Time		<i>Penicillium</i> sp. with PDA			<i>Penicillium</i> sp. with Spores		
				Observations			Observations
t ₄	Inoculated samples Before Cleaning			- Biological colonization (A); - Mycelium growth (A); - Spores reach the surface edge (B);			- Biological colonization (I); - Mycelium growth from spores contour (hyphae reaches the sample edges) (I); - Staining and deposition of elements (J);
	Inoculated samples After Cleaning			- Etching produced by hyphae (C , D); - Chromatic alterations (spots, stains and iridescence) (C); - Deposition of elements (C); - Biopitting (C,D);			- Chromatic alterations (spots, stains) (K); - Deposition of elements (K); - Crystal formation (L);
t ₆	Inoculated samples Before Cleaning			- Mycelium is more dense than t ₄ (E,F) and covers all the sample surface (F); - Crystal formation (F);			- Mycelium is more dense (M) (it covers all the sample surface and contours the sample edge) (N);
	Inoculated samples After Cleaning			- Etching produced by hyphae (G); - Chromatic alterations (stains) (H); - Deposition of elements and biopitting (G,H); - Crystal formation (H).			- Etching produced by hyphae (contours the sample edge)(O); - Increasing chromatic alterations (spots and stains)(P); -Increasing deposition of elements (P) and biopitting (O); - Crystal formation (P).

For the samples with *Penicillium* sp. and PDA before the cleaning procedure, at 4 months after the inoculation (Table 5 A and B), biological colonization was observed and although the mycelium is more dense near the PDA it is possible to see that this fungi grow and their hyphae reaches the sample edges (Table 5 B). *Penicillium* sp. also produced stains in this samples (Table 5 A) After 6 months (Table 5 E and F), the mycelium becomes more dense and it covers all the sample surface. Crystal formation can also be seen (Table 5 F).

Regarding samples with *Penicillium* sp. and PDA after cleaning, at four and six months after the inoculation, etching produced by hyphae was observed as well as biopitting (Table 5 C, D and G); Chromatic alterations (spots, stains and iridescence) and biopitting were also noticed at 4 and 6 months after the inoculation (Table 5 D and G). Glass darkening and deterioration is often linked to fungi growth (Bartosik et al., 2010).

Deposition of elements were also noticed at 4 and 6 months after the inoculation (Table 5 D, G and H). Deposits formed in the glass surface can be associated to the reaction between glass components and mold metabolites (Drewello and Weismann, 1997; Bartosik et al., 2007). Carmona et al., 2006 reported that biofilm interaction with glass cause serious damage on “historical stained glass windows not only from a chemical point of view but also from an aesthetic and iconographic one, since glass loses its transparency”. The same assumption applies to Spruce pine Batch 87 because it is mainly used by contemporary art artists and the loss of glass transparency creates a great damage from an aesthetic and iconographic point of view.

The experiment with *Penicillium* sp. spores also shows that 4 months after the inoculation, all the inoculated samples have biological colonization and mycelium growth (hyphae reaches the sample edges) (Table 5 I). At this stage, we also noticed that there is crystal formation only after 4 months. The observed surface alterations increased after 6 months. In addition, it is also possible to see that after 6 months the hyphae fingerprint is very visible after cleaning procedure in all inoculated samples (Table 5 O). Therefore, mycelium was strongly anchored on the glass surface.

Penicillium sp. spores present a mycelium density smaller than *Penicillium* sp. with PDA. Therefore, the nutritional source (PDA) is an important factor for the fungal growth but it is not a decisive factor, since only with the spores fungal grow was observed.

Figure 57A shows the control sample before incubation and Figure 57B show *Penicillium* sp. control sample after 6 months of incubation.

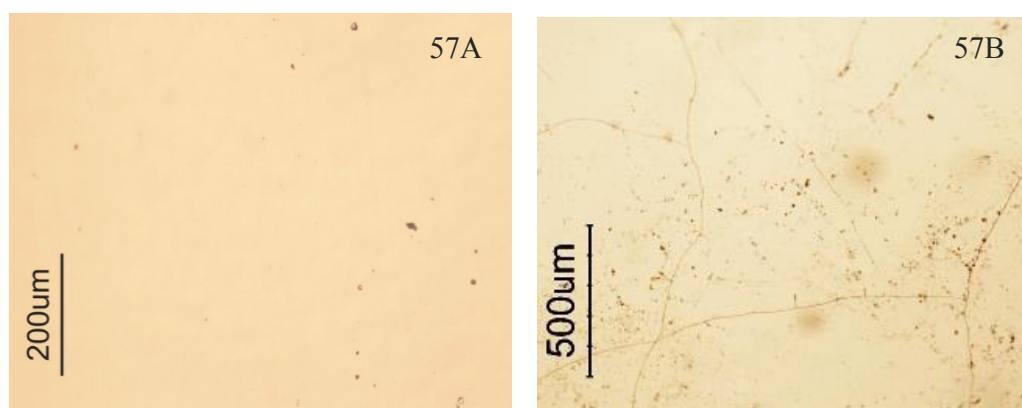


figure 57 - *Penicillium* sp. control sample before incubation (A) and after 6 months of incubation (B)

Fig 57A presents the glass control sample before the inoculation of the remaining glass samples. Since the control samples were incubated in the same petri dish, during the incubation period, some spores fly from inoculated samples to the control. Therefore, fig 57B shows that there is biological colonization and hyphae growth in the control samples after 6 months of incubation but they are much less dense than the inoculated samples. These control samples were sterilized before the inoculation of the remaining samples and the glass had no culture media or Tween. This indicates that fungi can colonize and grow in new glass with no culture media, just by dust particles. Krumbein et al., 1991 reported that some fungi are able to acquire the elements needed for growth from the deteriorating glass. The ability of fungi to grow on nutrient-free media with the only addition of silica containing compounds was also previously reported (Wainwright et al., 1997 in Gorbushina and Palinska, 1999).

In this work we can see 3 nutrient levels: just glass samples, spores with Tween and fungi with PDA. The spores flew off the samples with fungi into the control samples. Therefore, we can see hyphae fingerprints in all control samples after 6 months (fig. 57B). Control samples are a typical example of indoor artworks without cleaning after 6 months. Samples with spores and Tween (an organic cleaning agent) represent outdoor artworks (see Table 5 M, N), where we can see organic depositions. Finally, samples with fungi and PDA (see Table 5 E, F) represent a community which is already processing organic matter (for example, bacteria actinomycetes and foliage).

Table 6 presents the optical microscopy observations made on glass samples inoculated with *Aspergillus* sp. after 4 and 6 months of incubation (before and after the cleaning procedure). The results show the inoculated fungal samples with PDA and the ones just with spores. Figure 58A shows the control sample before incubation and figure 58B shows *Aspergillus* sp. control sample after 6 months of incubation. Control samples (fig. 58B) show spots and stains after 6 months but there is no mycelium growth.

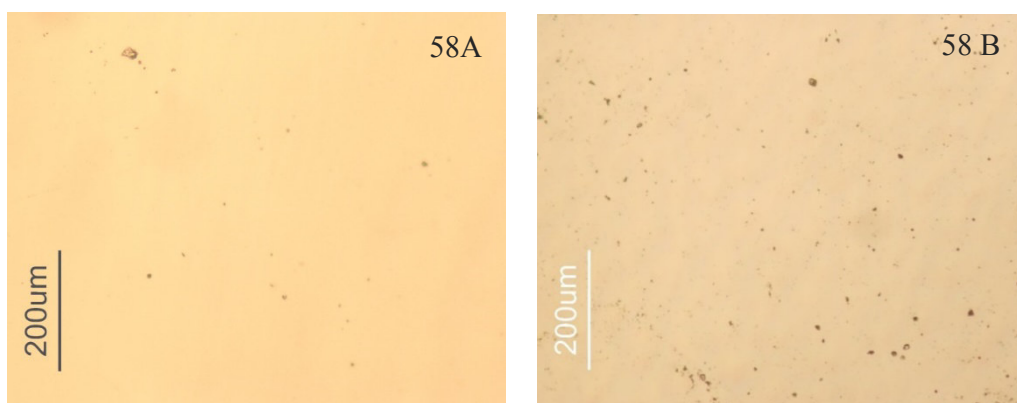

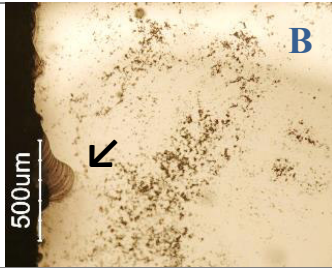
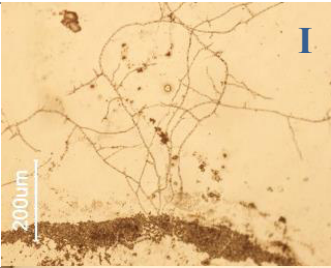
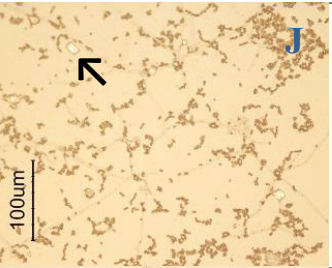
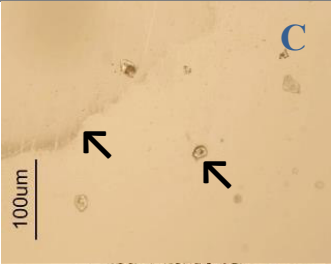
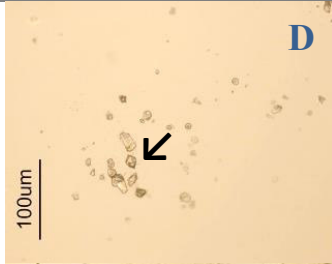
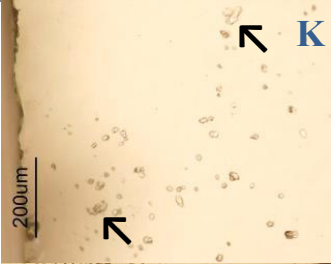

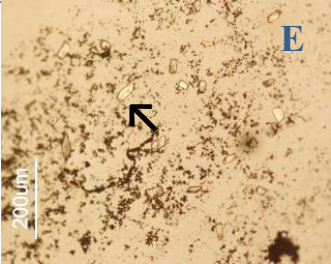
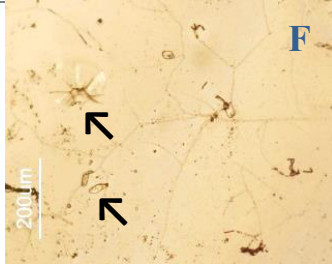
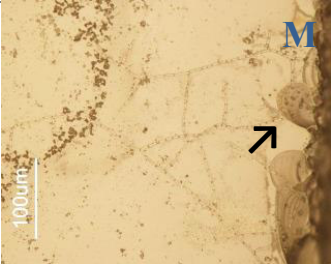
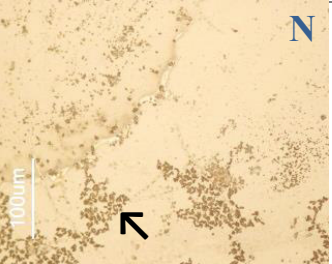
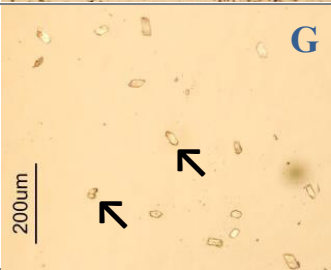
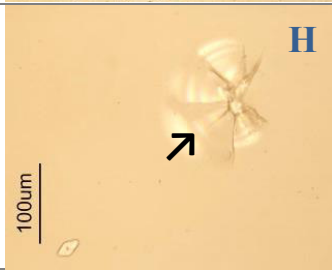
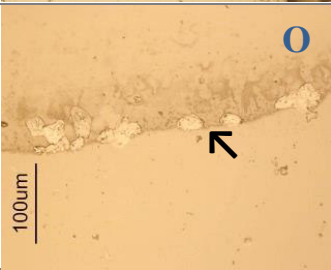
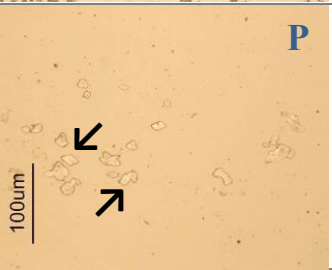


figure 58 –*Aspergillus* sp. control sample before incubation (A) and 6 months after the inoculation (B)

Table 6 - Optical microscopy observations of the glass surface 4 and 6months after of incubation with *Aspergillus* sp.

Time		<i>Aspergillus</i> sp. (PDA)			<i>Aspergillus</i> sp. (Spores)		
				Observations			Observations
t ₄	Inoculated samples Before Cleaning			- Biological colonization (A); - Mycelium growth (A); - Spores reach the surface edge (B);			- Biological colonization (I, J); - Mycelium growth (I); - Crystal formation (J);
	Inoculated samples After Cleaning			- Chromatic alterations (spots, stains) (C); - Deposition of elements (D); - Biopitting (C); - Crystal formation (D);			- Deposition of elements (K) and Biopitting) (K); - Crystal formation (K); - Etching produced by hyphae (L);
t ₆	Inoculated samples Before Cleaning			- Mycelium density is similar to 4 months (E); - Increasing deposition of crystals (E, F); - Micro cracks formation (F);			- Mycelium density is similar to 4 months (M); - Mycelium contours the sample edge (M); - Increasing stains (N);
	Inoculated samples After Cleaning			- Increasing crystal formation (G). - Increasing depositions (G), pits and micro cracks formation(H).			- Increasing chromatic alterations (spots, stains and iridescence) (O); - Increasing crystal formation (P). - Increasing biopitting (O).

From Table 6 A and B it is possible to see that, for samples with *Aspergillus* sp. with PDA after 4 months of inoculation, all the inoculated samples have biological colonization and mycelium growth but hyphae does not reach the sample edges in contrast to *Penicillium* sp. with PDA after 4 months of inoculation (Table 5 B). In addition, *Aspergillus* sp. with PDA after 4 months of inoculation, shows deposition of elements, biopitting and crystal formation (Table 6 C, D) as well as *Penicillium* sp. with PDA after 4 months of inoculation (Table 5 C, D). It is denoted, however, that the etching patterns differ according to the fungi specimen. *Aspergillus* sp. shows irregularly dispersed biopitting on the glass surface (Table 5 C, D) and *Penicillium* sp. shows more hyphae fingerprints and craters localized inside or nearby the hyphae fingerprints (Table 5 C, D).

After 6 months all inoculated samples show a mycelium density similar to 4 months. *Aspergillus* sp. with PDA mycelium is less dense than *Penicillium* sp. with PDA mycelium. After the cleaning procedure we can observe that there is an increasing deposition of crystals and other structures and there are also pits and micro-cracks formation. Kerner Gang et al., 1968 also reports pits in the glass surface caused by *Aspergillus versicolor* conidia (spores). The growth of conidia and glass biodeterioration was also reported in previous investigations (Bartosik, 2010).

For samples with *Aspergillus* sp. Spores, optical microscopy shows that after 4 months, all the inoculated samples have biological colonization and mycelium growth (Table 6 I, J). Hyphae does not reach the sample edges in contrast to *Penicillium* sp. Spores after 4 months of inoculation (Table 5 I). *Aspergillus* sp. Spores also show crystal formation after 4 months (Table 6 K) and hyphae fingerprints (Table 6 L).

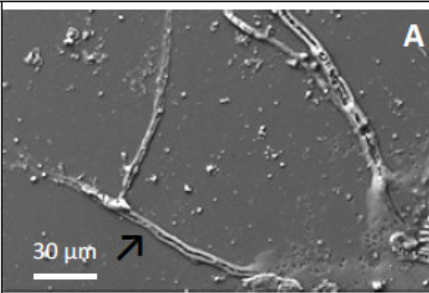
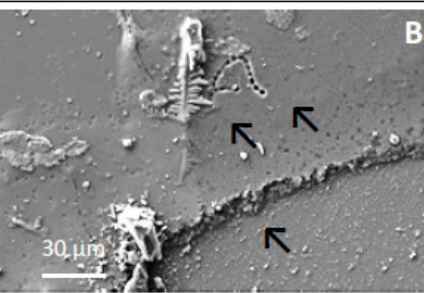
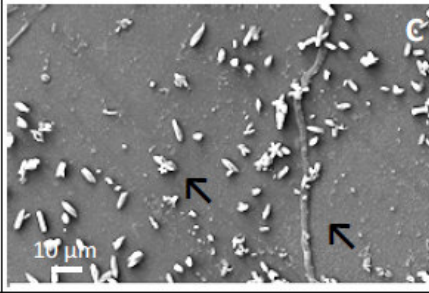
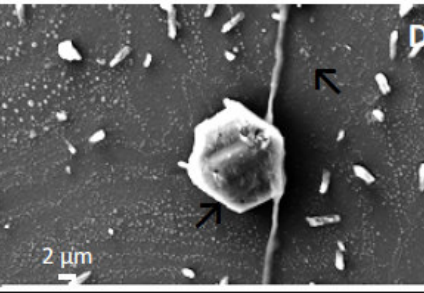
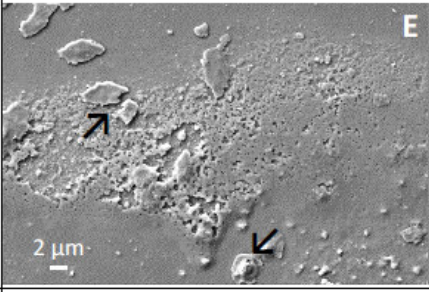
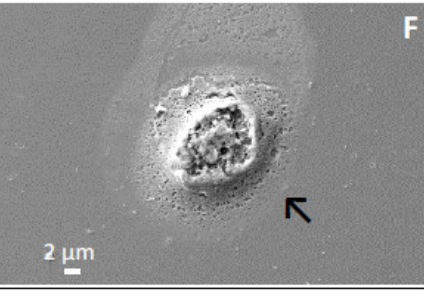
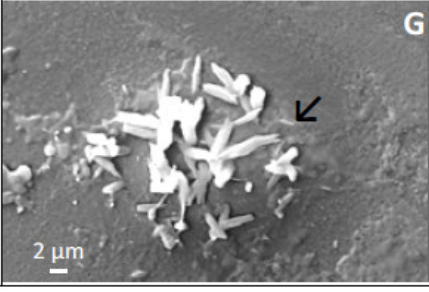
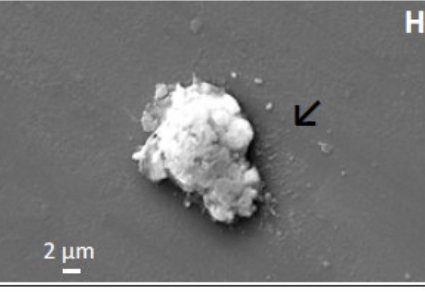
After 6 months, *Aspergillus* sp. Spores mycelium density is similar to 4 months but it reaches the sample edges (Table 6 M). In addition, *Aspergillus* sp. Spores mycelium after 6 months is less dense than *Penicillium* sp. spores after 6 months (Table 5 M, N).

Therefore, we can also assume that the PDA does not play an important factor for *Aspergillus* sp. fungal growth. Additionally, we can see that this genera is able to grow on nutrient free media. Also, in this experiment, the PDA does not increase the mycelium density. However, after the cleaning procedure we can observe that *Aspergillus* sp. with PDA (Table 6 G,H) produces more crystals than *Aspergillus* sp. spores (Table 6 O, P).

3.4 SEM-EDS results

SEM-EDS analysis allowed us to observe physical and chemical alterations caused by the inoculated fungal strains on the glass surfaces, complementing the optical microscopy observations. Table 6 presents the SEM-EDS results for *Penicillium* sp.

Table 7- SEM observations of the glass samples inoculated with *Penicillium* sp. obtained at 4 and 6 months after the inoculation.

		Observations	
<i>Penicillium</i> s.p. with PDA	t ₄	 	<ul style="list-style-type: none"> - Deposition of elements (A,B); - Hyphae fingerprints (A); - Spores fingerprints (B); - Depletion of elements (B); - Crystal formation (B);
	t ₆	 	<ul style="list-style-type: none"> - Increasing crystal formation and deposition of elements (C,D); - Hyphae fingerprints (C,D).
<i>Penicillium</i> s.p. SPORES	t ₄	 	<ul style="list-style-type: none"> - Deposition (E) and depletion of elements (E,F);
	t ₆	 	<ul style="list-style-type: none"> - Crystal formation (G); - Deposition of elements (H).

For the SEM analysis, all the samples were previously cleaned. SEM-EDS observations show that all inoculated *Penicillium* sp. with PDA samples presented depletion and deposition of elements, hyphae fingerprints and crystal formation after 4 months of incubation (Table 7 A, B). Figure 59 shows crystal formation related to a sharp increase of Ca.

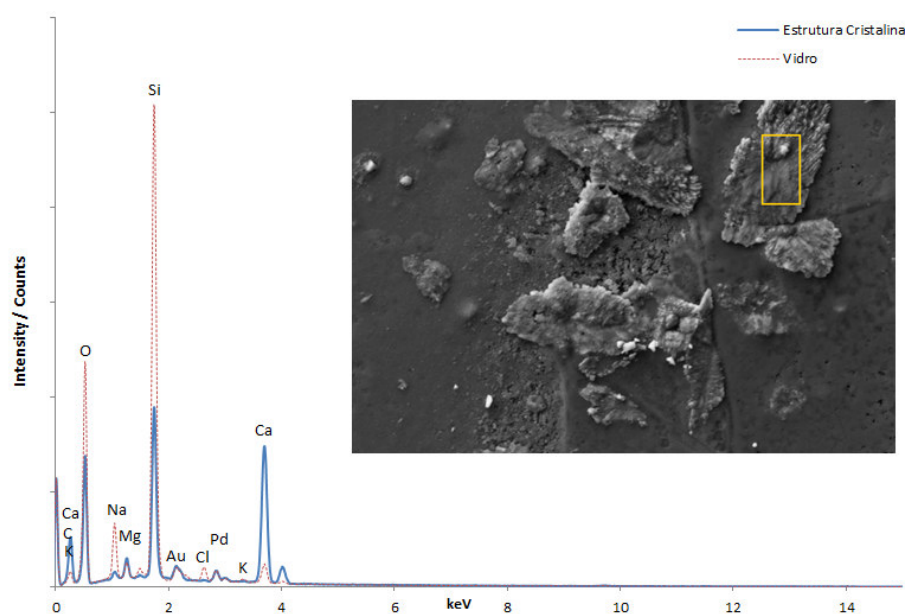


figure 59 - SEM-EDS analysis spectra of the glass surface 4 months after the inoculation of *Penicillium* sp. with PDA. Photography of crystal formation in the glass surface.

Figure 60 shows crystal formation related to the enrichment of other elements such as Na and Cl.

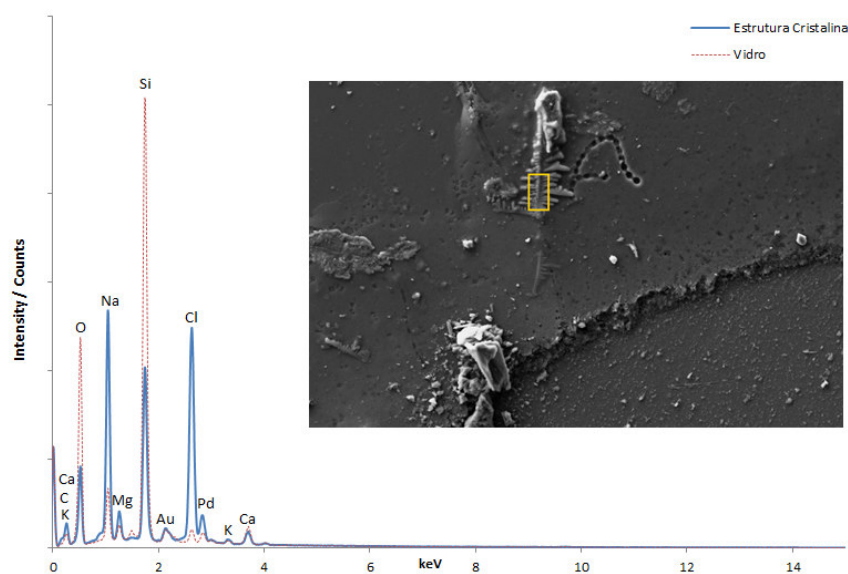


figure 60 - SEM-EDS analysis spectra of the glass surface 4 months after the inoculation of *Penicillium* sp. with PDA. The image shows crystal formation nearby fungi spores fingerprints.

There was an increase in the quantity of crystals in all inoculated samples with *Penicillium* sp. and PDA after 6 months (Table 7 C, D) and they are also related to the increasing of some elements, namely Ca and Na (see fig 61).

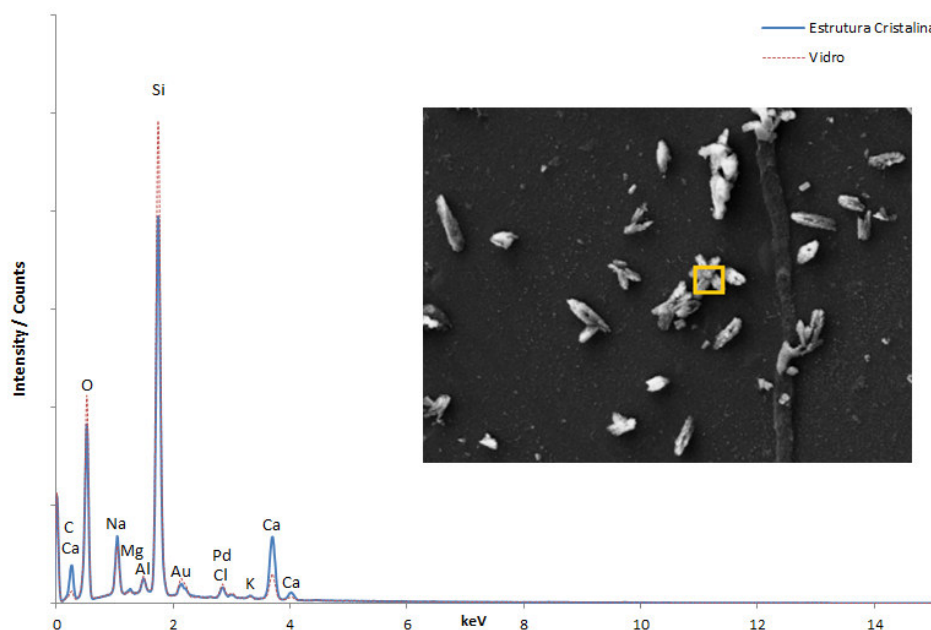


figure 61 - SEM-EDS analysis spectra of the glass surface 6 months after the inoculation of *Penicillium* sp. with PDA. The rectangle in the figure shows crystal formation in the glass surface.

SEM-EDS observations show that all inoculated *Penicillium* sp. Spores samples have depletion and deposition of elements after 4 months of inoculation (Table 7 E, F). The depletion of elements is related to the decreasing of Na and Ca (see fig. 62).

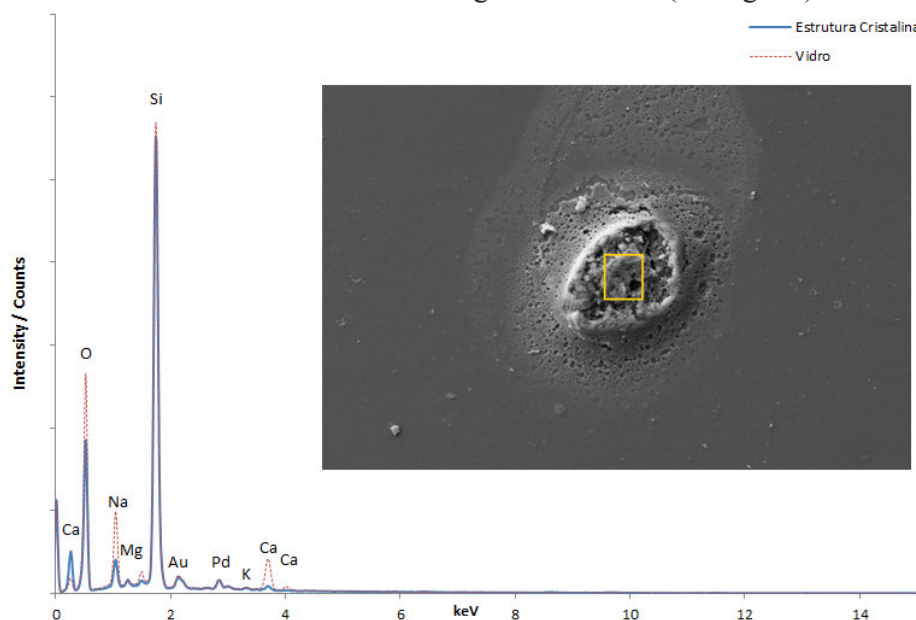


figure 62 - SEM-EDS analysis spectra of the glass surface at 4 months after the inoculation of *Penicillium* sp. spores. The rectangle in the figure shows depletion of elements in the glass surface.

The deposition of elements is usually related to the increasing of Ca and decreasing of Na (see fig. 63). Calcium carbonate presence was also confirmed in previous investigations (Drewello et al., 2000).

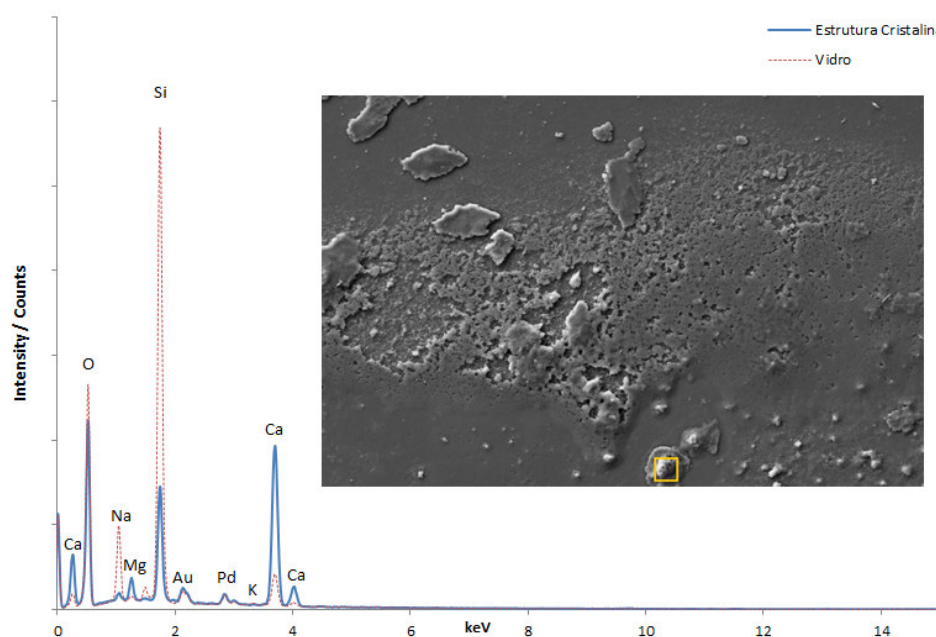


figure 63 - SEM-EDS analysis spectra of the glass surface at 4 months after the inoculation of *Penicillium* sp. spores. The rectangle in the figure shows deposition of elements in the glass surface.

We can also observe crystal formation and deposition of elements after 6 months in all *Penicillium* sp. spores inoculated samples (Table 7 G, H). Just as *Penicillium* sp. with Spores 4 months, the deposition of elements is also related to the enrichment of Ca (fig. 64).

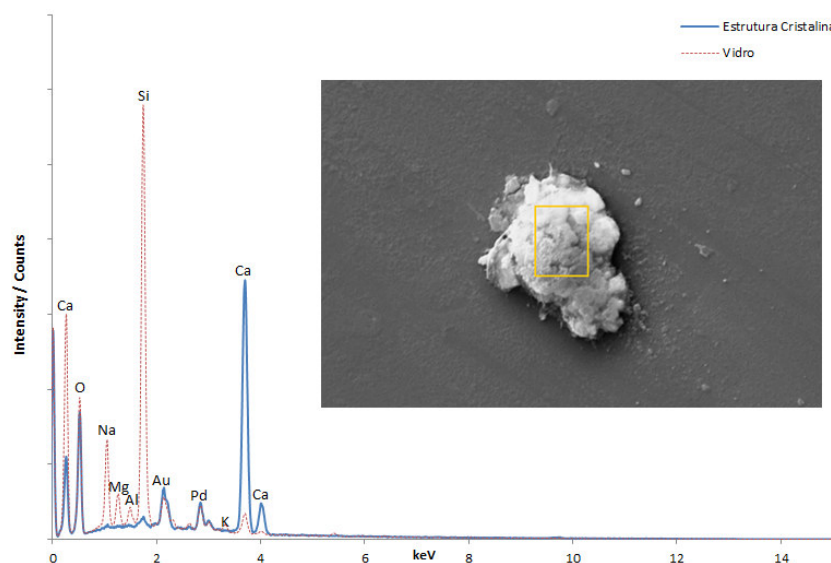


figure 64 - SEM-EDS analysis spectra of the glass surface at 6 months after the inoculation of *Penicillium* sp. spores. The rectangle in the figure shows deposition of elements in the glass surface.

Table 8- SEM observations of the samples inoculated with *Aspergillus* sp. obtained at 4 and 6 months after the inoculation.

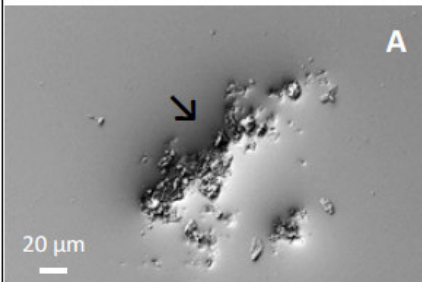
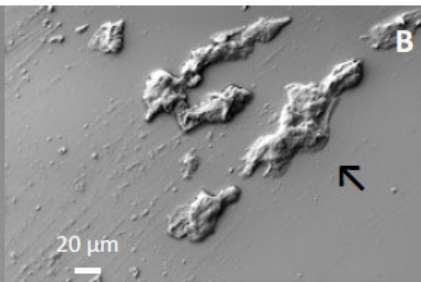
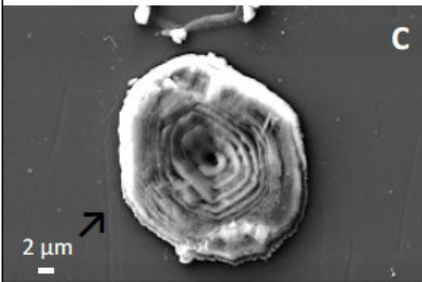
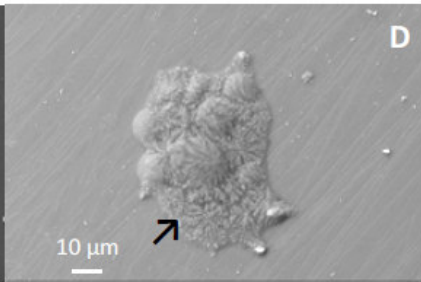
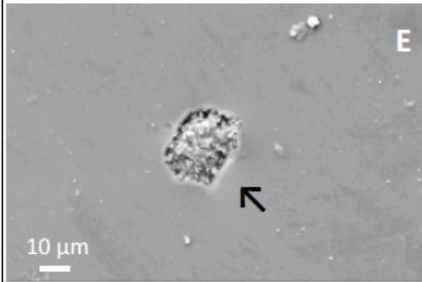
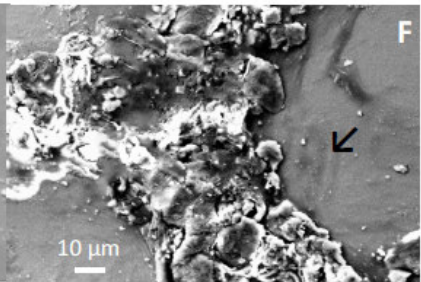
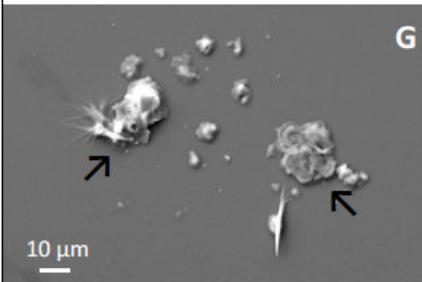
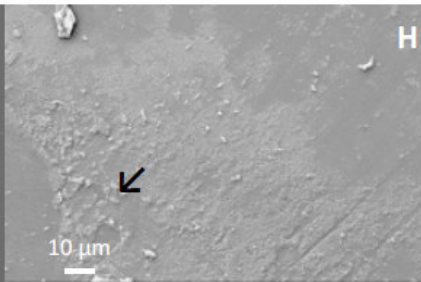
				Observations
<i>Aspergillus</i> s.p. with PDA	t ₄			<ul style="list-style-type: none"> - Deposition of elements (B); - Biopitting (A); - Depletion of elements (A);
	t ₆			<ul style="list-style-type: none"> - Crystal formation (C,D). - Deposition of elements (C,D);
<i>Aspergillus</i> s.p. SPORES	t ₄			<ul style="list-style-type: none"> - Deposition of elements (F); - Biopitting (E); - Depletion of elements (E);
	t ₆			<ul style="list-style-type: none"> - Crystal formation (G); - Deposition of elements (G); - Depletion of elements (H).

Table 8 presents the SEM-EDS results for *Aspergillus* sp. *Aspergillus* sp. with PDA inoculated samples presented depletion and deposition of elements only 4 months after the inoculation (Table 8 A, B). The depletion of elements is related to the decreasing of Na and Ca (see fig. 65). The observed depletion of Na and Ca can be attributed to microbial corrosion (Krumbein at al., 1991; Rodrigues et al., 2014). We can also observe crystal formation after 6 months in all inoculated samples (Table 8 C, D).

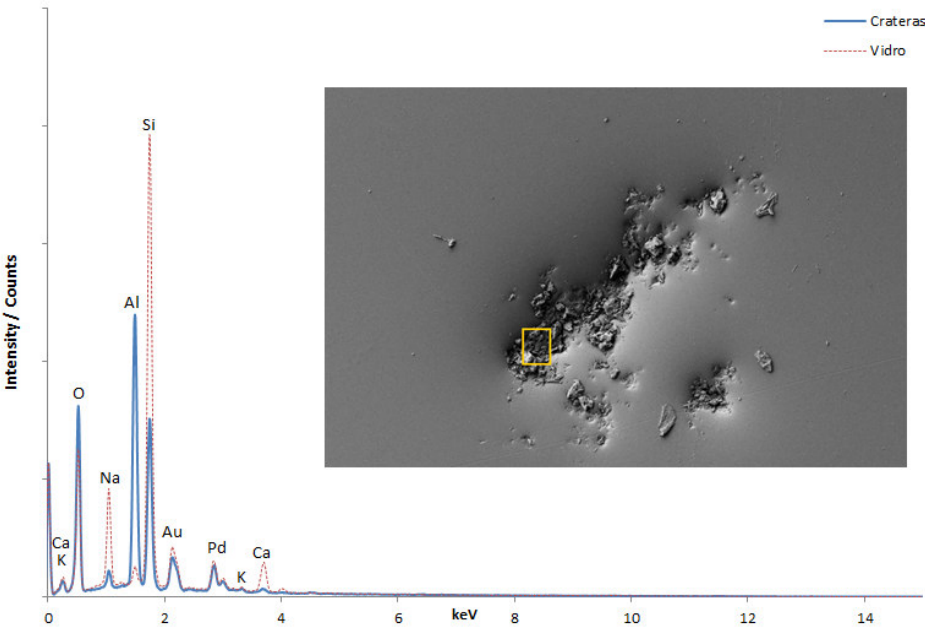


figure 65 - SEM-EDS analysis spectra of the glass surface at 4 months after the inoculation with *Aspergillus* sp. With PDA. The yellow square surroundings an area with depletion of elements.

The crystal formation and deposition of elements is related to the enrichment of Ca (see fig 66).

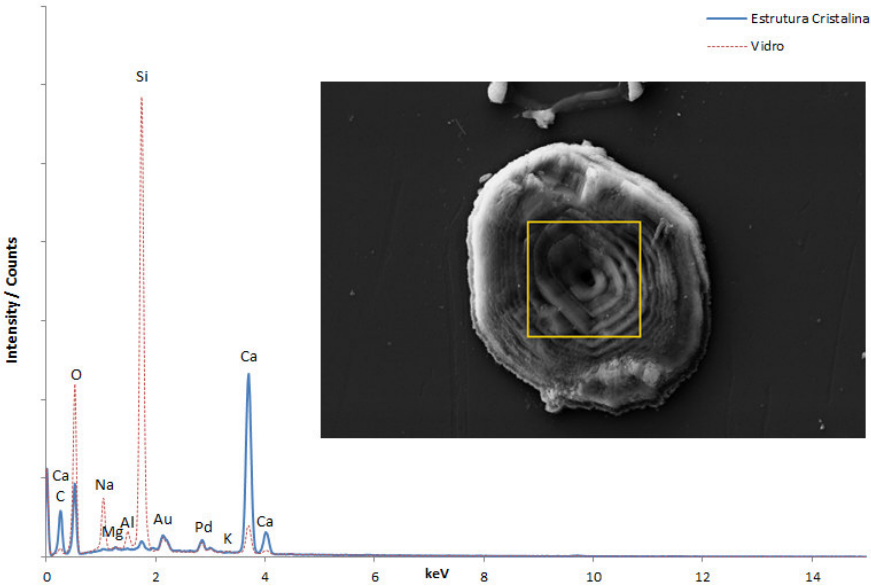


figure 66 - SEM-EDS analysis spectra of the glass surface at 6 months after the inoculation with *Aspergillus* sp. with PDA. The rectangle in the figure shows crystal formation in the glass surface.

Aspergillus sp. Spores SEM-EDS observations show that all inoculated samples have depletion and deposition of elements after 4 months (Table 8 E, F). The depletion of elements is also related to the decreasing of Na and Ca (see fig. 67).

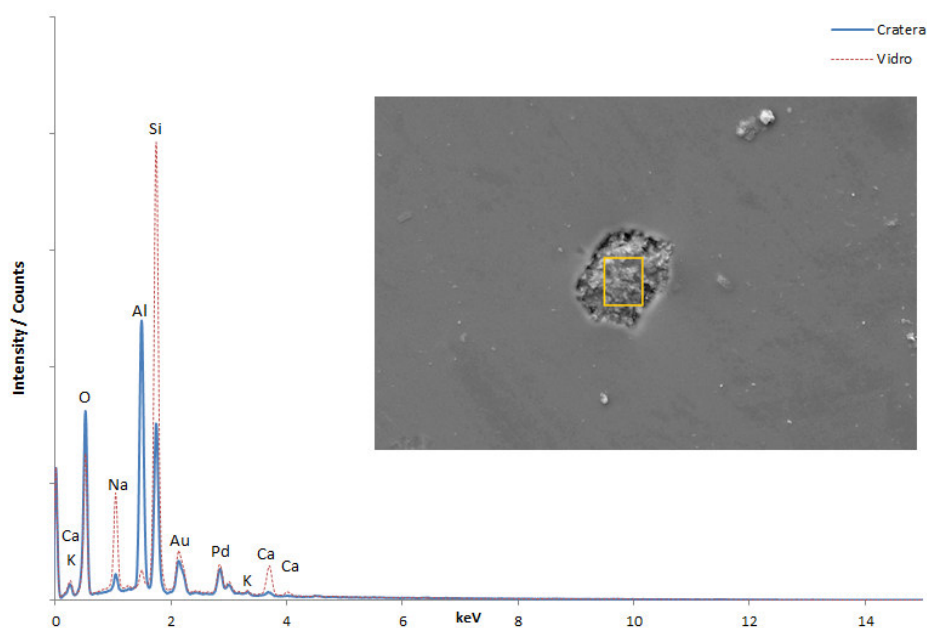


figure 67 - SEM-EDS analysis spectra of the glass surface at 4 months after the inoculation with *Aspergillus* sp. and Spores. The rectangle in the figure shows depletion of elements in the glass surface.

We can also observe crystal formation after 6 months in all inoculated samples (Table 8 G, H). The crystal formation and deposition of elements are related to the enrichment of Ca (see fig. 68).

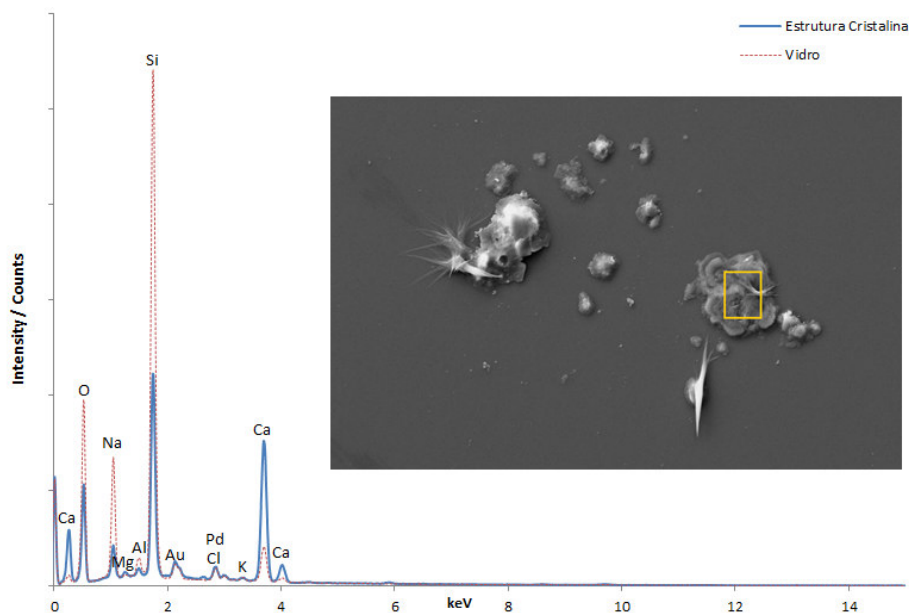


figure 68 - SEM-EDS analysis spectra of the glass surface at 6 months after the inoculation with *Aspergillus* sp. and Spores. The rectangle in the figure shows crystal formation in the glass surface.

3.5 μ -RAMAN analysis

μ – Raman analysis show us that minerals remained in the glass after the cleaning procedure. The same was also reported by other authors (Gorbushina and Palinska, 1999, Rodrigues et al., 2014). Both crystalline structures found on our experiment (CaCO_3 and $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$) are rich in Ca. Drewello and Weissmann (1997) reported that the enrichment of some elements in specific areas can be induced by biomineralization or produced by the mobilization of elements by microorganisms.

Calcium Carbonate is a common water corrosion product (Greiner-Wronowa and Stoch, 1996 in Vilarigues and da Silva, 2006). It is present in *Penicillium* sp. with PDA samples inoculated for 6 months, however it is not observed in control samples. Therefore, we presume that fungi also play an important role in calcium carbonate formation.

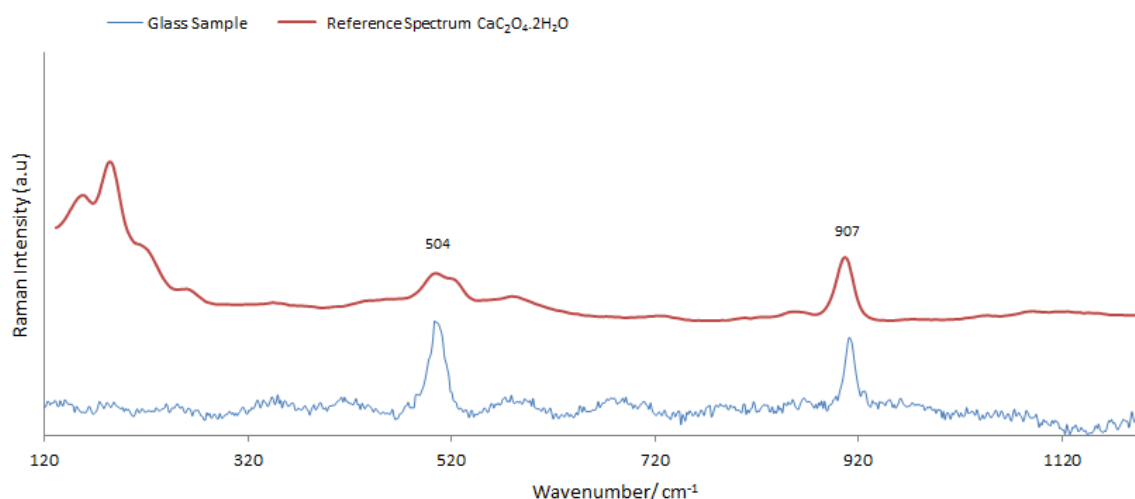


figure 69 - RAMAN analysis spectra of the glass surface at 6 months of incubation with *Penicillium* sp. and PDA

Raman spectra of the glass surfaces were made after cleaning the samples. Figure 69 spectrum shows 2 peaks at 504 cm^{-1} and 907 cm^{-1} ; these peaks are well related with the reference spectra of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$.

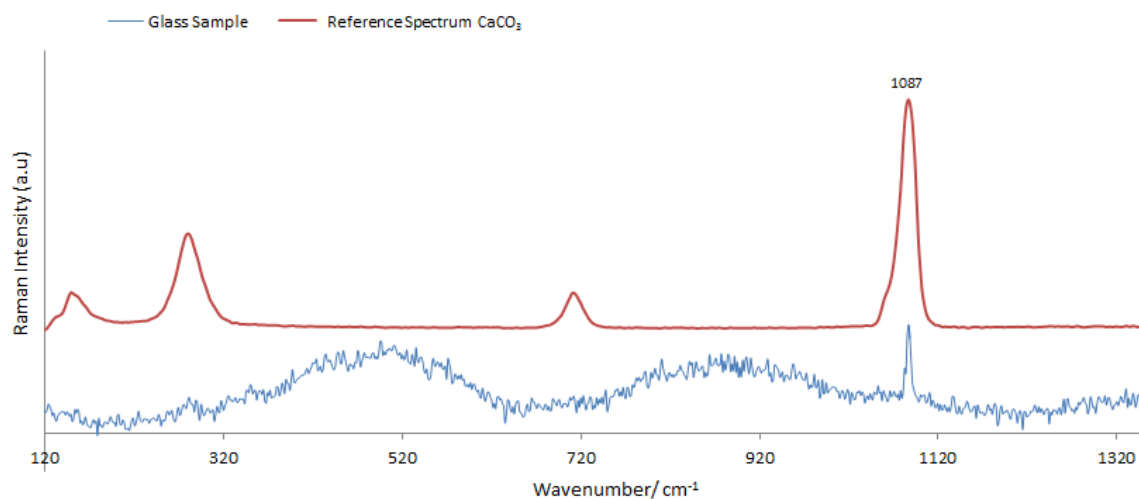


figure 70 - RAMAN analysis spectra of the glass surface at 6 months of incubation with *Penicillium* sp. spores

Figure 70 spectrum shows 1 intense peak at 1087 cm^{-1} ; this peak is well related with the reference spectra of CaCO_3 .

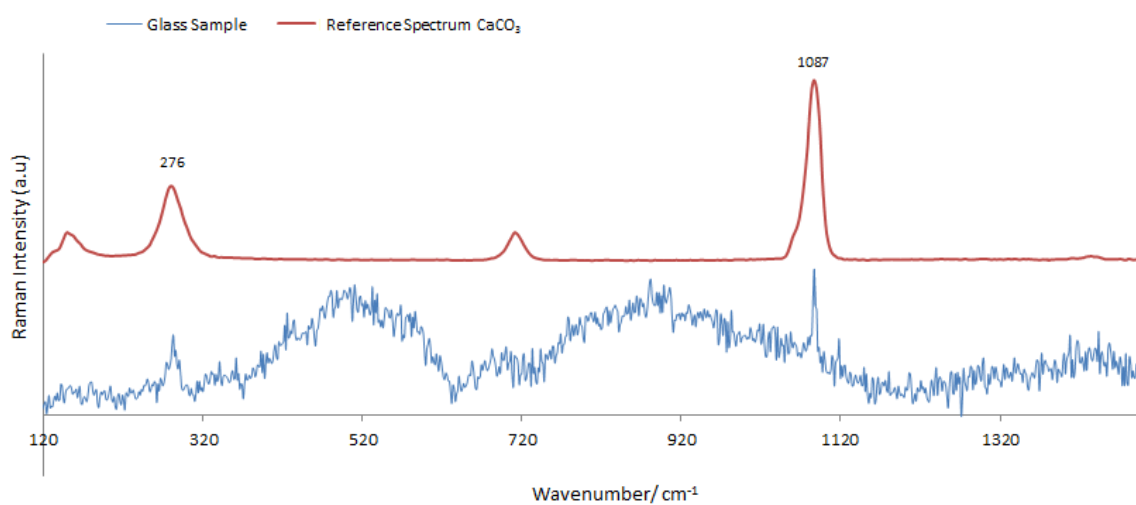


figure 71 - RAMAN analysis spectra of the glass surface at 6 months with *Aspergillus* sp. and PDA

Figure 71 spectrum shows 2 intense peaks at 276 cm^{-1} and 1087 cm^{-1} ; these peaks are related with the reference spectra of CaCO_3 .

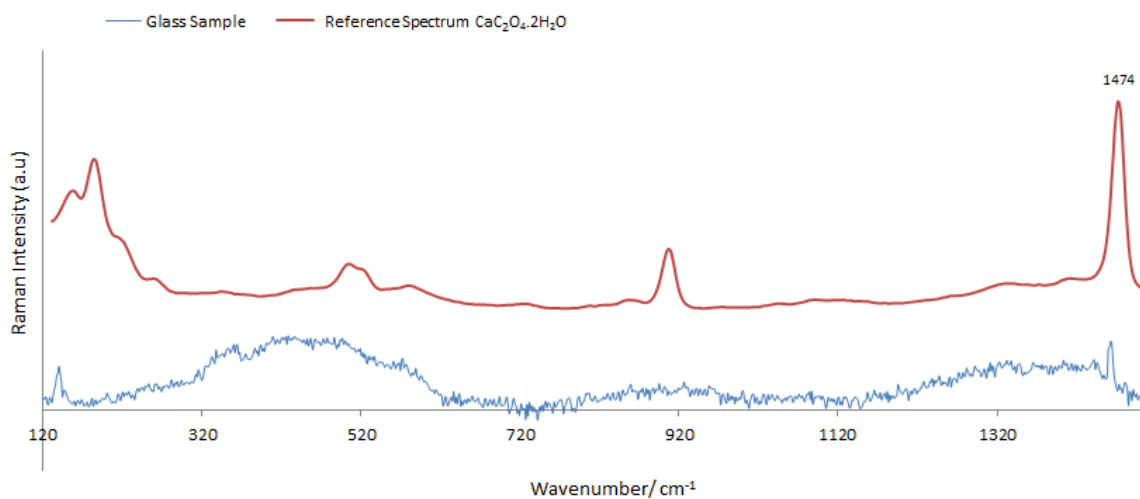


figure 72 - RAMAN analysis spectra of the glass surface at 6 months with *Aspergillus* sp. Spores.

Figure 72 spectrum shows 1 intense peak at 1474 cm^{-1} ; this peak is well related with the reference spectra of $\text{CaC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$.

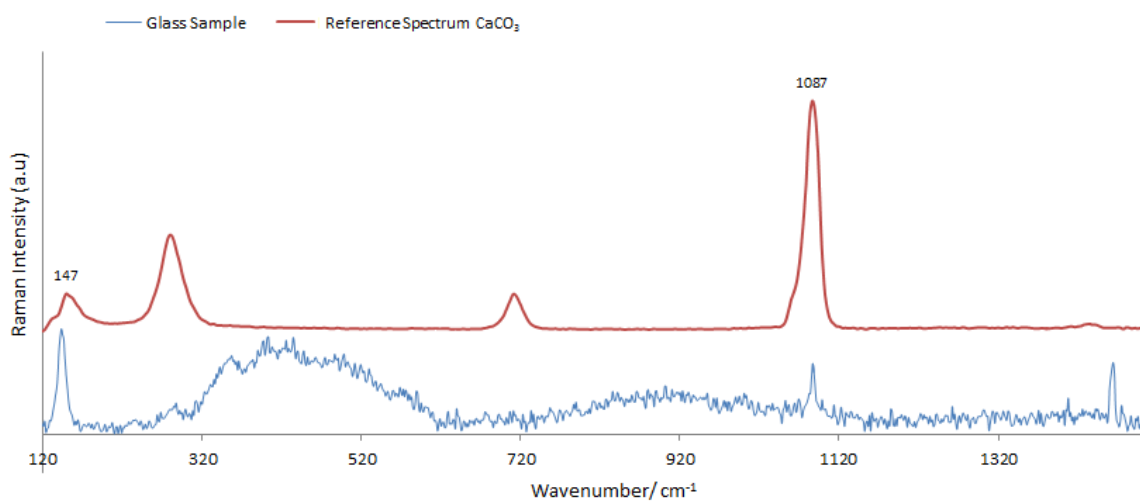


figure 73 - RAMAN analysis spectra of the glass surface at 6 months with *Aspergillus* sp. Spores.

Figure 73 spectrum shows 1 intense peak at 1474 cm^{-1} ; this peak is well related with the reference spectra of CaCO_3 .

Table 9 - Crystalline Structures found in the glass samples (μ -Raman)

	<i>Penicillium</i> sp. with PDA	<i>Penicillium</i> sp. with Spores	<i>Penicillium</i> Control	<i>Aspergillus</i> sp. with PDA	<i>Aspergillus</i> sp. with Spores	<i>Aspergillus</i> Control
t ₄	-	-	-	-	-	-
t ₆	CaC ₂ O ₄ .H ₂ O	CaCO ₃	-	CaCO ₃	CaCO ₃ CaC ₂ O ₄ .H ₂ O	-

Table 9 shows us that crystalline structures (CaCO₃ and CaC₂O₄.H₂O) are present in both *Aspergillus* sp. and *Penicillium* sp. samples after 6 months. These crystalline structures were not found in the control samples.

The presence crystalline structures was also reported by other authors (Gorbushina and Palinska, 1999, Rodrigues et al., 2014) and (Drewello and Weissmann, 1997) confirms that microorganisms can induce biomineralization and the enrichment of some elements. Therefore, we presume that both fungi also play an important role in calcium carbonate formation.

Table 10 - Damages after 4 and 6 months – Comparative Analysis (scale 0-4)

Parameters		<i>Penicillium</i> sp			<i>Aspergillus</i> s.p		
		Control	Fungi and PDA	Fungi Spores	Control	Fungi and PDA	Fungi Spores
Mycelium growth	t ₄	1	3	3	0	3	3
	t ₆	1	4	4	0	3	3
Chromatic Alteration (stains, iridescence, darkening)	t ₄	0	4	3	0	2	1
	t ₆	0	3	3	0	2	2
Biopitting	t ₄	0	3	2	0	3	2
	t ₆	0	3	3	0	4	3
Depositions	t ₄	1	3	3	1	2	2
	t ₆	1	3	3	2	3	2
Crystals	t ₄	0	2	0	0	3	2
	t ₆	0	3	2	0	4	2
Corrosion	t ₄	0	3	2	0	2	2
	t ₆	1	4	3	1	3	3

Regarding Table 10 we can see that:

- In both cases the control samples were contaminated. However, the mycelium was only observed on *Penicillium* sp. samples;
- After 6 months, the chromatic alterations and mycelium growth produced by *Penicillium* sp. was also bigger than the one produced by *Aspergillus* sp.;
- After 6 months, the biopitting and crystals produced by *Aspergillus* sp. were bigger than the ones produced by *Penicillium* sp.;
- Comparison between *Penicillium* sp. with PDA and spores after 6 months of inoculation shows that that there were no major differences with the exception of production of crystals and overall corrosion;
- Comparison between *Aspergillus* sp. with PDA and spores after 6 months of inoculation shows that that the main differences are the increase of crystals, biopitting and overall corrosion.

4 - CONCLUSIONS

Optical microscopy shows that only after 4 months, all the inoculated samples have biological colonization and mycelium growth. It is also possible to verify that mycelium growth is related to crystal formation, deposition of elements and chromatic alterations (spots and stains). The observed surface alterations increased until 6 months of incubation.

Penicillium sp. hyphae fingerprints were more visible than *Aspergillus* sp. The glass samples with PDA produced more damages than the ones without PDA.

SEM-EDS results show that only after 4 months of incubation (t_4) there is a formation of crystalline substances and depletion of elements in all inoculated glasses, in concordance with the optical microscopy results.

The observed surface alterations increased until 6 months of incubation (t_6). The depletion of elements (micro-cracks and craters in the glass surface) was related to the decreasing of some elements (Ca, Na) and it can be attributed to microbial corrosion (Krumbein et al., 1991).

The formation of crystalline substances was usually related to the enrichment of some elements, namely Ca (*Aspergillus* sp.) and Na, Cl, and Ca (*Penicillium* sp.). Drewello and Weissmann (1997) reported that the enrichment of some elements in specific areas can be produced by the mobilization or deposition of elements by microorganisms or induced by biomineralization.

μ -Raman analysis also shows us that minerals remained in the glass after the cleaning procedure. Crystalline structures (CaCO_3 and $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$) are present in both *Aspergillus* sp. and *Penicillium* sp. samples (with spores and with PDA) after 6 months. These crystalline structures were not found in the control samples. The presence of this crystalline structures also confirms that microorganisms can induce biomineralization and the enrichment of some elements. Therefore, we presume that both fungi also play an important role in calcium carbonate formation.

Therefore, both fungus genders (*Penicillium* sp. and *Aspergillus* sp.) produced enrichment of some elements, depletion and crystal formation. *Penicillium* sp. hyphae fingerprints were more visible than *Aspergillus* sp. and mycelium was also more dense than *Aspergillus* sp. *Aspergillus* sp. produced micro-cracks in some samples.

Concerning the conservation of Spruce-Pine Batch glass, it is noticed that the cleaning procedure (a 1:1 solution of water:ethanol) does not completely remove the fungi. The same fact was also reported by Rodrigues et al., 2014. Therefore, further research should be done regarding glass cleaning procedures.

Finally, concerning the nutritional source, the glass samples without PDA also showed mycelium growth and glass biodeterioration. Further studies should be done regarding the fungus spores inoculation without PDA in order to understand if the 0.05% tween solution (a common procedure to inoculate spores without a nutritive culture medium) also influences the fungus growth.

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Between Man and Matter

(the intimacy of matter through life and heat)

Portuguese to English translation

INTRODUCTION

“Nature does not adapt to our way of thinking. It is our job to change the way we think in order to adapt to nature.”¹⁰

Hubert Reeves, (1981)

Theme, issues and variables under study, aim of the research

The present dissertation is called «between man and matter (the intimacy of matter through life and heat)». The thematic area in question (the relationship between man and matter) was developed in a master's degree academic context. It has arisen from the need of a personal and professional development through a scientific and artistic articulation.

Theoretical and conceptual elements were selected in order to develop this exploratory study. Also, the scientific research was developed taking into account the material glass. The inseparable articulation between the theoretical-practical knowledge gave rise to two art exhibitions. Therefore, the present investigation method consists in a reflection/action/articulation dynamic which contributes to the construction/deconstruction cycle of the knowledge.

What is the intimacy of matter? This was the starting point of our investigation. What is matter? How might we grasp its intimacy? These were the questions which gave rise to the delimitation of two variables: the action of life and the action of heat on matter. Therefore, and in the context of the Master of Glass Art and Science, we focused on a reflection about matter in general (living and non-living matter) and we followed Gaston Bachelard's line of thought. The poietic act emerges from this theoretical-practical investigation. The presented artworks are traces of intimacy of matter, and despite being unutterable, the intimacy of matter leaves a clear trail of visibility.

The starting point is still open. Nonetheless, we outline some possible ways to proceed in the future, the ways of reflection, investigation and creative action within art and science.

¹⁰ REEVES, Hubert, *Um pouco mais de azul. A evolução cósmica*, Gradiva, Lisboa, 1984, p.161.

Thematic framework

In the second half of the 19th century and during all of the 20th century, the world witnessed a profound deconstruction of the classic paradigm. The scientific rationality matrix opened to multiple approaches, instead of one universal model. Contemporary science “is based in the replacement of this tranquillity by a non-accidental disquietude, inseparably linked to a non-Cartesian epistemology” (Freitas Branco: 1989, 212). In the case of physics and chemistry, *impermanence* becomes the base of all procedural mechanisms, contrasting with the classical principles of permanence and immutability. It is within science itself that the *becoming*¹¹ concept takes place. “It is present in different scientific fields, like biology astrophysics, sociology and physics” (Freitas Branco: 1989, 215). Therefore, contemporary science is concerned with the possibility of understanding the *inner motion* of all things. We denote that this *inner motion* is not a process of repetition but an articulation of different factors or discordant elements. The classical meaning of *definition* is also called into question because the object of science is now the *becoming phenomenon*. All of these changes within science also deconstruct the *truth* meaning. Contemporary science implies a *relative truth* and a *truth-conducive* process.

It should be emphasised that Quantum Mechanics and The Theory of Relativity did not replace the classical principles. What we learned is that the classical principles “have a relative validity; they are only applicable to a certain experimental area, and not to all of reality” (Freitas Branco: 1989, 215).

Therefore, the *matter* concept exists within a multiple, undetermined and nebulous universe. *Matter reveals itself as becoming*. The image increases from an incomplete and endless matrix field. The relationship between man and matter is built upon multiple perspectives and not only from one point of view. The exercise is developed in a double sense: between the cosmological world and the infinitely small world. The limits are explored through the action tracks or vestiges.

The interconnection between reason and imagination leads us to a humanizing concept, “we begin to understand that Earth is the place of life, not judgement” (Tchernichvsky cit. by White: 2008, 23). In this context, the *poietic act* opens space for creation and *we are able to invert the dwelling sense*.

¹¹ “Contemporary science «assumes the concept of *becoming* as the base for the mental processes»” (Bento Jesus Caraça cit. by Freitas Branco: 1989, 215).

PART 1

the individual – between reason and imagination

“The man’s nest, the man’s world never ends. And imagination helps us to continue it. The poet can never abandon such a great image, or more exactly, this image cannot abandon its poet.”¹²

Gaston Bachelard, 1957

Let us focus on Bachelard’s thoughts, from which we can isolate two faculties: reason and imagination. Their relationship takes place in the individual (the human being) and his openness to reality. “Bachelard’s metaphysics is an immanent aspect that exists in all his work about epistemology and phenomenology of imagination” (Simão: 2010, 17).

Bachelard’s *individual* is characterized by the *becoming* concept and he recognizes himself in a universe where “all the shapes are touched by an essential fluidity” (Simão: 2010, 23). *Reason* and *imagination* are also self-conductive (they constitute themselves).

In the work «Poetics of Space», Bachelard dedicates a chapter – «The House. From Cellar to Attic. The significance of the Hut» – “to the human condition, «from the attic rationality to the cellar irrationality»” (Simão: 2010, 29). When the *individual* wanders inside the house, he also travels inside himself. The articulation between reason and irrationality is made by another creative and dialectic faculty, *imagination*. Bachelard (1989: 36) states, “Verticality is ensured by the polarity of cellar and attic, the marks of which are so deep, that in a way, they open up two very different perspectives for a phenomenology of the imagination.” Indeed, the roof reveals its function right away: it gives mankind shelter from the rain and the sun he most fears. Geographers remind us that the slope of the roof is one of the surest indicators of a region climate. A bigger slope averts rain clouds or snow. A smaller slope (a horizontal roof) indicates a region where the rain clouds are scarce and the wind is gentle. In these regions the intensity of the sun is big and the roof terraces become

¹² BACHELARD, Gaston, *A Poética do Espaço*, Martins Fontes, São Paulo, Brasil, 1989, p.116.

places where the man dries fruits. In the attic “it is a pleasure to see the bare rafters of the strong framework. Here, we participate in the carpenter’s solid geometry” (Bachelard:1989, 36).

“In the cellar, we shall no doubt find uses for it (...) But it is first and foremost the dark entity of the house, the one that partakes of subterranean forces. When we dream with the cellar, we are in harmony with the irrationality of the depths.” (Bachelard: 1989, 37) It is in the house’s depths that the human being is able to dig into the earth intimacy. “As for the cellar, the impassionate inhabitant digs and re-digs deeper and deeper, making its very depth active. The fact is not enough, the dream is at work. When it comes to excavated ground, dreams have no limit.” (Bachelard: 1989, 37)

The house is imagined like a *vertical and concentrated being*: *verticality* is raised by the polarity between cellar and attic and *concentration* reveals the primitive refugee, the simplicity centre of the house.

Human beings inhabit this dual vertical polarity. If we go to the attics (if we dream of the heights) we may have fear, but we are in the rational zone. Therefore, rationalization will be always faster and clearer; the day experience can always dissipate the night’s darkness. In the cellar, darkness prevails, night and day. Bachelard (1989: 38) tells us “even when we are carrying a lighted candle, we see shadows dancing on the dark walls” Even in our civilization (which has electric light everywhere), “the unconscious cannot be civilized. It takes the candle when it goes to the cellar.” (Bachelard: 1989, 38). The human being embraces the world beyond the cellar. The cellar walls are buried in the earth. These walls contain “the entire earth behind them. And so the situation grows more dramatic, and fear becomes exaggerated.” (Bachelard: 1989, 38).

In the work «Metáforas da Luz e do Saber», Frei Hermógenes Harada (2009) writes a small fable about the relationship between the house and the earth. This fable questions the human being’s openness to reality and also our objective knowledge limitations.

The author focuses in the metaphor behind the frog’s questioning: “«Is the Earth as large as the well?»» The Earth does not fit in the well because the well is contained in the Earth” (Harada: 2009, 122). The frog lives inside the well and tries to perceive the Earth from the well point of view. At a certain point in his reflection, the frog speaks loudly “«Bigger, smaller, as large as, these are all comparative terms. Comparison only makes sense inside a certain measurement from which I can then compare. This measurement, however, only

takes place in my world, because this measurement is born, lives and operates from my world point of view.»” (Harada: 2009, 122)

The suspicion of an Earth much bigger than his own home leads the frog to an inaudible intuition: “«Where does the *beyond-well* suspicion come from? How can I speak about nothing, not everything and nonbeing if the ‘other’ is not already present in myself? If I am hopelessly imprisoned in the well, I cannot even suspect about the existence of a non-well!»” (Harada: 2009, 122). This event, however, instead of easing up his knowledge, proves otherwise. *It is the knowledge transformation (the inaudible intuition that reveals the presence of the other)* that becomes the meaning of his life “«how do I know my not knowing?»” (Harada: 2009, 123).

An earthworm lived near the well. Earth is the worm house. “Like the fish lives in the water, the worm lives, insists in the humus, in the Earth essence. The worm is, so to speak, the Earth carnification; it is the place where the Earth opens and retracts, where it becomes sensibility, resonance and concentration.” (Harada: 2009, 123). One day, the worm listened to the frog’s monolog and answered: “I think that there is no answer to that question, because how can the involved one ask for the surroundings like the frog does? The frog lives in the Earth hole. Earth sustains the hole’s empty space. All Earth vibrations pervade and pulse inside the Earth hole (...) Earth space (...) can only be perceived if I become permeable and resonant with the Earth-vibrations. The frog, however, tries to perceive the Earth from objective measurements and comparative terms of *bigger than* and *smaller than*. The frog tries to embrace the Earth magnitude from these insufficient measurements. And he does not even realise that the dwell hole exists (it only has its own space) from the inside of the Earth that he wants to measure.»” (Harada: 2009, 123).

The being that reverberates the earth (the surrounding space) questions the being who lives inside the well. However, this metaphor tells us that the well is not enclosed by the ‘other’. The ‘negative’ of the Earth is sustained by the Earth itself. All the vibrations, intensities, frictions and openings of the Earth also pulse inside the well. However, Earth’s space can only be grasped if the being becomes resonant to its presence. The ‘negative’ of inhabiting function testifies the deconstruction of the dialectic relationship. The inhabited space begins to open up.

We would also like to look into the *concentration* faculty present in Bachelard’s work, *Poetics of Space*. Like we said before, *concentration* reveals the house as the primitive refuge (as the place for intimacy). Bachelard indicates several examples that seek to

discover “the taproot of inhabiting function” (Bachelard: 1989, 48): the hut, the house-universe dynamic and the nest.

In the imagination kingdom, winter increases the value of the inhabited house. “In the outside world, snow covers all tracks, blurs the road, muffles every sound and conceals all colours. As a result of this universal whiteness, we feel a cosmic negation in action. The house dreamer knows and senses all of this, and because of the diminished entity of the outside world, the dreamer experiences the qualities of intimacy with increased intensity” (Bachelard: 1989, 57). The house-universe dialectic increases and the poet Rilke presents us the reverse of inhabiting function: “In the house shelter, Rilke would like to be outside, not through any desire to enjoy the wind and the rain but to pursue his own reverie” (Rilke cit. by Bachelard: 1989, 59).

The ‘negative’ of inhabiting function is an example of the house-universe dialectic. The inhabited space opens to the outside and breaks the limits of geometrical space. “Sometimes the house grows, it spreads. In order to live in it, we need a reverie with greater elasticity; we need a less clearly outlined reverie” (Bachelard: 1989, 66).

Georges Spyridaki’s (1989) house breaths and transcends the Cartesian geometry. “My house (...) is diaphanous, but it is not made of glass. It is more of the nature of vapour. Its walls contract and expand as I desire. Sometimes, I hold them close to me, like an isolation armour. But at other times, I let my house’s walls expand into their own space, which is infinitely extensible” (Spyridaki cit. by Bachelard: 1989, 66).

The house becomes a psychic state and we need to search for its subtleties in order to approach the values of the inhabited house. Psychologist Françoise Minkowska¹³ studied the drawings of houses made by children. These drawings have the advantage of welcoming spontaneity and the child reveals his intimate dreams. “If the child is unhappy, the house bears the traces of his distress (...) closed houses (...) motionless things, houses that have become motionless in their rigidity (...) surrounding strait trees” (Bachelard: 1989, 85). However, the inhabited house always has its own fluidity. The house is shaped by the *signs* of our life¹⁴. The author gives us the door-knob example. “Its function takes precedence over any question of size. For it expresses the function of opening (...) only an objective mind could express that it is used to close as well as to open the door. In the values domain,

¹³ Minkowski, “Recueil d’articles 1923-19’65, Psychopathologie - Expression et langage - Phenomenologie”, Cahiers du Groupe Françoise Minkowska, Paris, 1965.

¹⁴ In semiotics, the *sign* is something that can be interpreted as having a meaning and it works through the other senses. The sign is intrinsically related to the object (the sign represents the object) and the interpretant (sign’s meaning).

the key closes more often than it opens. The door-knob opens more often than it closes. And the gesture of closing is always sharper, stronger and faster than the one of opening” (Bachelard: 1989, 85).

We started with the house-universe dynamic towards the creation of possible permeabilities between both. We now walk into the intimate experience of inhabiting. Bachelard (1989) dedicates the chapter *The Nest* to the relationship between beings and their refuges. The nest-house is the return *sign*. The bird returns to the nest every year, and with the passing of seasons, the bird’s house grows old but it is also successively rebuilt. “Human returning takes place in the great rhythm of human life, a rhythm that reaches back across the years and, through dream, fights all absence. House and nest both reveal an intimate component of faithful loyalty” (Bachelard: 1989, 111).

In this domain, Bachelard (1989) presents us *Michelet nest*¹⁵, where the shape is built from the inside. The bird’s tool is its own body, “it is the bird’s chest, with which it presses and tightens the materials until they become absolutely pliant, well blended and adapted to the general plan (...) It is by constantly turning around and pressing the walls that the bird succeeds in forming the nest circle. The female, a living lathe, hollows out its house” (Bachelard: 1989, 113).

If we go rationally deeper into the *nest* knowledge, we rapidly understand that this is a precarious construction, easily exposed to storms, “and yet it sets us to a security reverie” (Bachelard: 1989, 115). *The answer to this paradox is simple*, says the author, “in a sort of a naïve way, we relive the bird’s instinct (...) and we place ourselves at the origin of the confidence in the world” (Bachelard: 1989, 115).

In the work *Entre o Corpo e a Paisagem*, Armando Rabaça presents us *three ways of inhabiting* which reveal the primordial refuge instincts but also celebrates reason and man’s technical ability. The first inhabiting way is called “ \sqrt{geu} ”; the term derives from the greek term *gýpé*, which means *to live in a hole*” (Rabaça: 2011, 17). The term *gýpé* takes us back to a more profound meaning, related to our own body, or more precisely, “to the concave and convex shapes from our anatomical organs, which emphasises the intrinsic relationship between the cave and the womb” (Rabaça: 2011, 25). The second inhabiting way is called $\sqrt{*keu}$ and it gives rise to “words related to excavated places and temporary constructions” (Rabaça: 2011, 17). These words are also related to the action of a body that closes a pre-

¹⁵ Jules Michelet, filósofo e historiador, escreve o livro *L’oiseau*, do qual Bachelard retira os exemplos relacionados com a construção do ninho.

existing space, for example the act of covering a hole with a ceiling made of animal skin or branches. Human sedentism gives rise to the root word \sqrt{dem} , which originates “the greek word *domos* and the latin word *dómus*, house. This last root word is related to construction (...) to the ability to change the natural world” (Rabaça: 2011, 18). \sqrt{dem} represents the submission of matter to man’s will and technical ability.

The author refers that *the nature of inhabited spaces* “systematically alludes to architecture as an expression of the way humans perceive the world and also as a definition of man’s religious and cultural identity (...) this perception goes far beyond the shelter function; to inhabit is to conquer space, to transform space and to operate first and foremost with a respect for the holy” (Rabaça: 2011, 18).

The two first ways of inhabiting are related to nomadic people. In these cases, the selection of a place to inhabit is related to the primordial instinct for protection and shelter. The meaning of these words take us back to the “round shape, the most simple and elemental shape and the one that relates to a feeling of protection, refugee and shelter, or more precisely, to the one that relates to the embryonic stage” (Rabaça: 2011, 29). The relationship between nomadic people and landscape is dynamic and intimately related to the cycles of nature.

The third way of inhabiting is intrinsically related to reason and technical ability as the main structures that allow men to remain in one place permanently. The house becomes a permanent space that fits into the landscape scenery. Men build walls, enclosure houses, create borders and domesticate hostile territories. Man’s landscape has several fixed locations that reveal borders and space delimitations, but space experience or “space realization is intrinsically related to movement” (Rabaça: 2011, 54). The articulation between horizontal and vertical axes intensifies the relationship between men and the world: “the horizon as the line that delineates man’s space and differentiates sky from earth or sea” (Rabaça: 2011, 41) and earth itself, the limits of the earth, the exterior limits of a place.

In this context, João Barrento (2006) tells us that in 1976, the jewish artist Dani Karavan welcomed people in Venice Biennale Israeli pavilion with a phrase «Olive trees should be our borders. Karavan is an artist with the following guiding principle in artwork: “an encounter without landscape violation” (Barrento: 2006, 192). Nowadays, nomadism still exists, *but this is a different nomadism*, today’s nomadism is the symbol of exiles and persecutions. Today is still the day of “forced displacements of populations and not an

«unintentional compulsive wandering» that still exists in the seasonal animal genome” (Barrento: 2006, 193).

However, there is still the “*nomadic thinking*” (Barrento: 2006, 197). The author teaches us that “conventional is an adjective which does not apply to these two errant spirits, artist and philosopher. The nomadic thinking animates them and makes them move through all the imagination and thinking spaces. They have no borders, and yet they are always on the border” (Barrento: 2006, 197).

Therefore, the individual (*the being who lives inside the well*) spreads between the cracks which emerge inside the well, and the sky that surpasses vision. Earth’s reverberation becomes the reflection of the sky. The cracks open up in every sense and the ‘other’ veiled existence no longer is an inaudible intuition, but a sense of convergence which creates visibility. It is about seeing and grasping from the matter thickness, from its distortions and reflections. It is about paying attention to multiple articulations and becoming aware of the resonance between the being and the world. Perhaps, this is why the path is no longer operating in the universe, but allowing oneself to be drawn into the world.

This brings us back to Bachelard’s *human-house* dialectics (bird-house, vertical house, universe-house, intimate house) that search for the intrinsic meaning of *being-human*; in essence, Bachelard searches for the true nature of the human being and he finds it in both reason and imagination¹⁶.

¹⁶ For Bachelard, the power of imagination is not “to escape from the world, but to bring us back the world” (Veiga Simão 2010, 65).

matter rationalism

“We move from darkness into light and from light into darkness. And every time, we become terrified, with the fear of abandoning the world that we already know, with the fear of finishing, of coming into an end. But everything is just a passage to another universe, a new condition, a new world...”¹⁷

Rui Chafes, 2012

We dedicate this chapter to the articulation between different ways of approaching the concept of *matter*. These new methods of approach result from a paradigm shift which is born within contemporary science. “Space, time, determinism (...) they all became a complex problem (...) which means that the physical image of the world and the scientific and epistemological elements all changed profoundly” (Blanché¹⁸ 1983, 11). The *a priori* conception of Space and Time (the main principle of classical thinking of permanence and causality) is deconstructed within science. Therefore, through the use of different scales (that range from the infinitely small world to the infinitely large world), it is possible to create multiple articulations between men and matter.

We begin our path towards the scale reduction. In the studies about the nature of matter, Bachelard (1990) first analyses the ancient concepts related to the four elements of nature. He then gives rise to the intermaterial properties which we can only access through science (using both reason and scientific instruments).

Matter exists in its plurality, and there is a fundamental difference between the quotidian reality and the infinitely small world (the world of the atom): the access to the atomic nucleus is only possible through science.

In fact, it is about “understanding an educated materialism” (Veiga Simão: 2010, 32) and putting the accessibility to different reality levels into question. Therefore, although classical physics distinguishes energy from matter, atomic physics combines the terms. An

¹⁷ CHAFES, Rui, *Entre o céu e a terra*, Documenta, Lisboa, 2012, p.40;

¹⁸ Philosopher (1898-1975), teacher at Toulouse University. His core work is related to Epistemology and Logic.

atom changes its shape because it receives and releases energy. In this process, there is a reconversion of energy into matter, a '*becoming*' or an evolution from irradiation towards the corpuscle.

Matter transactions become a fundamental point in contemporary scientific thinking: *matter organizes itself into shapes*.

Form, the external shape, is no longer in contradiction with the matter of which it is composed. Matter is the potential principal that changes the shape. Therefore, *both matter and shape become*. *Becoming not being* is about the process of change. It brings us focus on *verbs instead of nouns*. It brings us focus in the process, in the nature of transience.

“In view of these ideas, how can we not see the priority of matter over shape? Matter gives rise to shapes; it manifests directly its transformation ability. Therefore, matter is released from the shape imprisonment. Matter is not carved from the outside; it is not imposed from the outside” (Bachelard: 1990, 26). It is the *transactions between matter*, “the actions of matter over matter” (Bachelard: 1990, 18) that define both matter and shape as becoming.

Time’s action over matter also brings us to a plural dimension. The object as a sign of matter and the permanence of exteriority are conditions that we need to understand more deeply. “If anything, shape and object are only an instant of matter. Temporal conditions of matter transactions and substance mixtures are deeply inscribed into matter” (Bachelard: 1990, 26).

When we approach our hands or when we touch something, says Eugene Chudnovsky¹⁹ “my hand’s electrons are repealed from the other body’s electrons, and this is why my hand cannot pass through your body” (Chudnovsky cit. by PUNSET: 2009, 54). Punset adds, “If it were not so, we would be swallowed by the earth (...) what we’re saying is that *we are walking in a cloud of electrons*. We’re not pasted to the soil, because as you said, if there were no electrons, we would pass through it” (Punset: 2009, 54).

Matter adds itself to the unknown. As the scale reduces, atoms are replaced by nucleus, quarks and springs. *Atoms are replaced by the incompleteness of knowledge*.

“In the past, let’s say, twenty years ago, we assumed that everything was formed by particles, a kind of very small particles, we may call spherical particles. But now, we know

¹⁹ Chudnovsky is a physicist; he teaches at the New York University and his core work is related to macroscopical quantic effects in magnets and superconductors.

that there are objects which are not made of atoms and they may even be very large, for instance, the chords” (Chudnovsky cit. by Punset: 2009, 54). *But also other kinds of matter:* the “astrophysics mystery, the so called *dark matter* (...) experience demonstrates that the only way to explain gravitational forces and the evolution of the universe – the attraction between different objects – is assuming that the universe’s mass is much bigger than what we observe” (Chudnovsky cit. by Punset: 2009, 53).

This means that there are substances that we cannot yet access, but they exist in the universe and they constitute it profoundly. Dark matter’s presence is inferred from forces that move away from astronomical objects: however, this type of matter does not interact (or interacts in a way that we cannot perceive) with light waves or with the matter that we observe. *Dark matter inhabits us through its effects, through the action trails*²⁰.

Until the end of the 20th century, we thought that the universe’s expansion was slowing down due to the gravity effects (the force by which physical bodies attract each other). However, in 1998, the Hubble telescope showed that very distant supernovae were expanding slower than today’s Universe (*not to forget that observing the stars is looking into the past*²¹). The Hubble telescope discovery led to the following inference: the universe’s expansion is not slowing down, but successively accelerating. *There is a mysterious force, invisible to ‘our eyes’, that accelerates the Universe’s expansion.* We do not see it but we infer its presence by the observation of its effects.

In the book «O Espírito Nómada» Keneth White (2008:260) speaks about the possibility of establishing a “new coordinate system that follows the «trail lines».” The author says, “It’s a new way of proceeding, a new way of walking» (...) «the remaining velocity of a vessel that no longer has a pulling engine», but also «animal trails». As you can see, it is a very rich concept, a concept that speaks about walking, sea and animal.” *The ‘trail lines’ give rise to the creation of new possible articulations.*

In this context, Gonçalo M. Tavares (2013:112) raises the following questions: “From which angle do you see the world? From which angle do you see the other? (...) What are these gestures which interfere with the personal and intern lucidity? Let us propose a

²⁰ “Dark matter is not visible, although its presence and distribution is found indirectly through its effects. Dark matter can act like a magnifying glass, bending and distorting light from galaxies and clusters behind it. Astronomers can use this effect called gravitational lensing to infer the presence of dark matter in massive galaxy clusters.” (Peroto and Villard: 2012)

²¹ For example, the Sun light takes 8 minutes to reach the Earth. Distant supernovae observations allows us to study the beginning of the Universe.

hypothesis: these are thoughts, and thoughts are movements that interfere with events and with the world's interpretation. They change what we cannot see.”

Different observations give rise to multiple interpretations. The scientist's vision turns the attention towards the understanding of what is observed; in this process “he makes a decision for certain elements and certain combinations (instead of others), and therefore follows a general view, a theory which rationally links the different elements” (Tavares: 2013, 65). It is therefore an analogy or an articulation which allows us to associate elements without becoming a tautology. Thought is also a process of change, *it becomes* and it multiplies continuously through new connections: “all we can do is to change the way of thinking (...) and to persuade other people to change their way of thinking” (Wittgenstein: 1991, 58). Gonçalo M. Tavares (2013:67) adds, “a group of investigators decides, almost by implicit voting (...) in which analogy do we trust (...) When we discuss if truth is indeed truth or false, we are again discussing – and contesting – the privileged analogies, the chosen connections.” *It is about the intuition that truth is multiple and also a conducive process.*

The subject's complexity focuses on the different articulations between men and nature. “We are too large to see the infinitely small world but we are too small to see galaxies (...) We are somewhere between the cosmology and the particle physics, the smallest things in the world” (Glashow²² cit. by Punset: 2009, 59).

Once again, says Bachelard (1989:185), “we are stuck in the dialectics of the deep and the large; the infinitely small that deepens and the large which extends with no limit.”

²² Sheldon Lee Glashow, physicist. He received the Physics Nobel Prize in 1979, together with Abdus Salame and Steven Weinberg, for their contribution to the theory of the unified weak and electromagnetic interaction between elementary particles.

Table 1 – Units equivalence table²³

units	Equivalence (metres)	examples
	10^{-18} m	electron diameter / quark
femtometre (fm)	10^{-15} m	proton radius – 1 fm
picometre (pm)	10^{-12} m	50-600 pm, atomic diameter
nanometre (nm)	10^{-9} m	0,1 nm, hydrogen atom diameter
micrometre (μ m)	10^{-6} m	0,1 μ m, HIV retrovirus radius
millimetre (mm)	10^{-3} m	9 mm, 5 weeks embryo
metre (m)	1 m	1,7 m, human being medium size
kilometre (km)	10^3 m	8,846 km, Everest mountain height
	10^6 m	6371 km, Earth radius
	10^9 m	$0,7 \times 10^6$ km, Sun Radius
light-second ²⁴ (s/l)	300 000 000 m	499 s/l, terrestrial orbit
light-hour (h/l)	$1,08 \times 10^{12}$ m	10 h/l, solar system radius
light-year (y/l)	$9,46 \times 10^{15}$ m	10^{15} a/l, Milky Way diameter
parsec ²⁵ (pc)	$3,085 \times 10^{16}$ m	$3-7 \times 10^9$ pc, visible universe radius

Wittgenstein (1992:14) raises the following question: “Is it correct to say that ‘it is difficult to say what true accuracy is’, since we only know rough approximations?”

Macrophysics relates the Strength of Materials subject to «soft mechanics». Studies within this order of magnitude “are not considered perfectly stiff (...) the main objective of Strength of Materials subject is to calculate the bodies deformation under loads” (Nash: 2001, 1). Ductile material visibly deforms. This material makes us perceive the fracture direction with our own eyes. Fragile materials break without notice. Newton’s laws apply to the construction of a shelter, a bridge or a house. *In our eyes scale, everything remains undisturbed.* However, ductility and fragility result from the microphysics. “The «soft mechanics» remains in the macrophysics perspective” (Bachelard: 1990, 23) but it cannot be conceived by the Heisenberg principle. The order of magnitude that defines the atomic world goes into the picometre or the femtometre scales, and these units can only be perceived by quantitative models and statistical methods of data processing.

²³ Table source: (Punset: 2009, 60)

²⁴ The light-second (s/l) is the distance that light travels in one second, in vacuum.

²⁵ The parsec (pc) is a unit of distance used to measure astronomical objects outside the solar system. The parsec annual parallax is 1 arch-second. Parallax is the difference in apparent position of an object viewed in two distinct places. The arch-second (1") is an angular measurement, from which we can make the following relation: the circle has 360°, 1° corresponds to 60' (60 arch-minutes) and 1' corresponds to 60", therefore, 1" corresponds to $1/(60 \times 60) = (1/3600)^\circ$.

We shall walk now towards an increasing scale. In the cosmological world, the dominant standard model is Albert Einstein's General Relativity Theory. This model conceives an intrinsic relationship between time-space-matter: matter's presence shapes the space-time curve and this curve affects matter's motion. The bigger the celestial body's mass, the greater the space-time curvature in the vicinity of the celestial body; therefore, due to space-time curvature, the celestial bodies with less mass, turn about the celestial bodies with bigger mass, as if they were attracted by the body with bigger mass.

In this context, Einstein postulated that no experience can distinguish between a body with an acceleration \vec{a} and a gravitational field \vec{g} ²⁶ (one of the observations that leads to this theory confirmation is the light curvature in a gravitational field²⁷). On the other hand, the Special Relativity Principle demonstrates the non-simultaneity between events - depending on the observer and the respective inertial frame of reference – and it is generalized by the General Relativity Theory for accelerated frames of reference²⁸.

*Time expansion*²⁹ and *Space contraction*³⁰ are two important concepts that characterize the Special Relativity Principle³¹. Relativity theory tells us that there is no absolute observer; it

²⁶ For example, if an astronaut throws an object inside a spaceship, the object approaches the floor, as if there is gravitational force. However, it is not the object that falls to the ground, but the spaceship ground that approaches the object as it travels up with a specific acceleration \vec{a} .

²⁷ Let us look into the previous example: an astronaut is inside a spaceship that travels with a specific acceleration \vec{a} . The astronaut observes a light beam coming in through the window. As the spaceship increases the velocity, the light beam becomes a parable, because the distance covered is successively increasing.

²⁸ Einstein's relativity principle also tells us that the speed of matter propagation is always inferior to the speed of light. Atoms and molecules which constitute matter are connected through electromagnetic fields, the same fields that constitute light. *To break the speed of light is to break the barriers which characterize visible matter.*

²⁹ Let us imagine a spaceship that travels at a certain speed \vec{v} with regard to a specific inertia frame of reference. Inside the spaceship, a light sign is emitted. It propagates in the perpendicular direction to the spaceship's movement and it is reflected in a mirror (also placed inside the spaceship). An observer, also inside the spaceship, measures the time interval elapsed between the emission and reception of the light sign. Another observer, located outside the spaceship (for example, in Earth), measures a bigger time interval between the light emission and reception. *There is a time dilatation, measured from an exterior frame of reference.*

³⁰ Let us imagine an observer inside a train and in the mid-way point of the carriages. The train travels at a certain speed \vec{v} between points A and B. Let us also imagine another observer, standing on the road, outside the train and in the middle point between A and B. In the instant when the train's geometric centre passes the middle point between A and B, two light flashes are emitted. In that instant, the observer that stands on the road, sees simultaneously the two flashes (for him, the flashes cover an equal distance); however the observer inside the train sees first the flash emitted in point B, because, as he travels inside the train, the covered distance by sign B is smaller than the one covered by sign A. For the train observer, the events are not simultaneous. *There is a length contraction towards the movement.*

³¹ If the spaceship's velocity is much smaller than light speed, the measured time interval is similar to both observers, which demonstrates that the special relativity principle contains the Galilean relativity. *Different articulation possibilities result from different points of view and also different working scales.*

tells us that each observation is observer-dependent (it depends on the observer's reference frame). Therefore, according to Relativity, an absolute objectivity is rationally unobtainable.

The Theory of Relativity also postulates that matter is a continuum; in other words, it is defined in a continuous way (it has a non-discrete structure). Einstein (1916: 83) states "I can get from any one point (...) to any other point by passing continuously from one point to a "neighbouring" one, and repeating this process a (large) number of times, or, in other words, by going from point to point without executing "jumps." (...) We express this property of the surface by describing the latter as continuum."

If we walk towards the 'infinite small that deepens', we also break the classical thinking principles. Time and space give rise to *the multiple*. "Relativity Theory is continuous and it was born in the moment when particle physics was governed by a non-continuous principle" (Blanché: 1983, 58). According to quantum mechanics, it is not possible to know with certainty the exact place and moment of a particle. When we walk towards the elemental and infinitely small world, *matter has a dual particle-like and wave-like behaviour*. In the infinitely small world *change occurs in quantum leaps*. But *matter organizes itself into shapes*. Therefore, *both matter and shape 'become' in quantum leaps*.

At the atomic level, the scientist questions the *demiurgic meaning* of the world. *Atoms are not eternal. They can be created or destroyed by men* via processes of energy. "When men joined both Heisenberg and Schrödinger theories, it was then possible to create and destroy particles that didn't exist before!" (Glasshow cit. by Punset: 2009, 67).

However, we also call into question the ability to create *living matter*. In the beginning of the 1950s, the biologist Stanley Miller and his team were able to synthesize amino acids. Subsequently, they tried to create polymers from the synthesized amino acids. The synthesized amino acids replication was not possible to achieve. So far, it is not possible to recreate life from synthesized molecules. Eugene Chudnovsky (2009:56) raises the question: "Why does that tree grow and grow without us being able to replicate this process in the laboratories, unless germinating the secrets from its own seed?" The author tells us that in a conversation with Stanley Miller, he asked him the following question: "«Why didn't you continue to create proteins and then life?». «I thought that I could do it in the following week, however I'm trying to do it for the past 40 years but I have still not been able to do it.», and this was Miller's answer".

We may build a reality theory in accordance with the reductionist thinking. In order to explain, for example, what a cup of glass is, we deepen our vision towards the infinite small word and its successive compartmentalization. However, the opposite is also possible; if we start from the infinitely small world, we may ask, for example, how do atoms have ability to create life? And then, how is it possible to create complex living organisms from the simplest living substances? When, by this process, animals are created, the cognition ability is also raised, therefore “instead of being only random atoms, they can make actions with a final purpose. And everything brings us back again to the mind (...) walking backwards, we reach the fundamental particles, although we can’t really realize their true fundament; on the other hand, we are able to recreate mind through the comprehension of things which were in the origins of life and evolution, until we reach the mind again” (Morowitz³² cit. by Punset: 2009, 50).

Life, the mystery of life lies in the fact that it is able to transmit, generation after generation, the genetic knowledge within the living matter. “Without a shadow of a doubt, biophysics and biochemists are able to create new molecules, and some of them are extremely complex; however, the ability to create new life, no one is capable of doing it” (Chudnovsky cit. by Punset: 2009, 55) except through the enigma pervaded in our own life.

Life thus shows a mysterious entropy inversion. The systems irreversibility is reversed. However, the second law of thermodynamics³³ sends all matter to degeneration, decay and finally, disappearance. The spontaneous evolution of isolated systems translates, sooner or later, into an entropy increase. Houses grow old and crack and all the stars eventually turn off. *One day, the Sun will also turn off.* Ilya Prigogine (2008) places the question in the context of dynamic systems instability. With life, “with the genetic code, we have an internal biological time which continues over thousands of years” (Prigogine: 2008, 68). The complexity of these evolutionary dynamic systems increases successively, for instance, “the primate brain has an intrinsic instability which allows for the creation of amplifications and polarizations in all directions” (Prigogine: 2008, 69). This preparation for complexity makes us rethink the second law of thermodynamics. In the first moments, the Universe was very small and extremely hot. In the beginning, it evolved towards an increasing complexity instead of an increasing degeneration, “structures appeared progressively at all levels, from stars until galaxies and biological systems” (Prigogine: 2008, 71). The author adds that at

³² Harold Morowitz is biophysicist. He lectured in Yale University and his core work is related to the study of living systems thermodynamics.

³³ Second Law of Thermodynamic – the Universe entropy increases in a continuous process and remains unaltered in an equilibrium process.

the cosmological level, the Universe reality is much more complex because we need to take in account gravity and also entropy. The question is still open, therefore inconclusive due to its profound complexity.

All in all, matter reveals an inner diversity that reinvents itself continuously and the great life lesson is that the future remains open. It is an evolving system which embraces multiple articulation possibilities, transformation processes, construction/deconstruction projects, autopoietic creation.

*“How does a project mature?
It is obviously a most mysterious,
imperceptible process.
It carries on independently of ourselves,
in the subconscious,
crystallizing on the walls of the soul.
It is the form of the soul
that makes it unique,
indeed only the soul decides
the hidden ‘gestation period’ of that image
which cannot be perceived
by the conscious gaze.”³⁴*

Andrei Tarkovsky, July 3, 1975

³⁴ Tarkovsky, Andrei, et al, *Instant Light, Tarkovsky Polaroids*, 2004 Thames and Hudson, United Kingdom.

PART 2

From Visual Perception to Reality Openness

“Because I am the size of what I see
And not the size of my stature”³⁵

Alberto Caeiro, 1925

We dedicate this chapter to the process of perception and to the possibility of exploring and reformulating the world’s experience through imagination. In the work *A Poética do Espaço*, Bachelard explains that “in the domain of scientific observation and with certain objectivity, the first time doesn’t count. Observation belongs in the domain of ‘several times’” (Bachelard: 1989, 164). In this context, Gonçalo M. Tavares tells us that “the formulas that describe facts, things and matter behaviours are numerical fixations of unaltered visions, numerical functions of confirmed visions or quantitative fixations of multiple observations” (Tavares: 2013, 371).

The notion of scientific progress is related to an exhaustive view of the world and it relies on observation instruments. “In scientific work, we have to psychologically digest our surprise” (Bachelard: 1989, 164). *Wonder* belongs to the part of the world that still escapes scientific observation.

In the artistic universe, a multiple and recurrent vision gives rise to a *first outlook*. “The imaginative outlook is the outlook that wants to be amazed; if he has already wondered about something and if he looks at it again, it’s because he wants to be amazed again and probably with a different detail” (Tavares: 2013, 372).

Artist and scientist approach and distant themselves from the referent. They may both rely on optical instruments or mechanisms which allow a change of scale. However, attention will always have two states of mind or “two ways of holding a magnifying glass” (Tavares:

³⁵ CAEIRO, Alberto, *O guardador de rebanhos*, Edição Alma Azul, Coimbra 2007 (1925 ed. original), p.12.

2013, 373). The scientist, in the encounter with novelty, seeks to repeat the first observation towards the discernment of the visible world (or towards the understanding of discernment patterns). On the other hand, the artist, in the encounter with novelty, leaves for another place, even if the cartesian space is still the same. *Imagination* allows us to create an area of freedom where the individual inhabits matter and merges with the world “in a confusion of lines that absolute rationality cannot understand” (Tavares: 2013, 374).

As a variation on the theme, we would like to present two examples, one from Merleau Ponty and another from the poet André Pieyre de Mandiargues³⁶. The poet approaches the surface and immerses in the visible. What he sees is the “body celebration” (Ponty: 2006, 6), it is the world’s approach through matter (through his own body’s matter and through the word’s matter). Ponty (2006:57) states, “When I see a square at the bottom of the pool, and through the thickness of the water, I do not see it despite the water or the reflexions; but I do see it because of them, through them. If these distortions, if the sunlight’s beams didn’t exist, if I saw the square geometry without my flesh, then, I would not see it anymore. Mandiargues says “Come nearer the window and try not to allow your attention to be too much focused in the outside. Until you have seen one of these kernels that are like glass cists, at times transparent little knucklebones, but almost always befogged or vaguely translucent, and with a long shape that reminds us the pupils of the cat’s eyes” (Mandiargues cit. by Bachelard: 1989, 165). But what happens to the outside world when it is seen through these glazed kernels? Under the poet’s guidance and through the glass cist, we see a multiplying world. To hold a magnifying glass is to pay attention, “but isn’t paying attention already having a magnifying glass? Attention, by itself is an enlarging glass” (Bachelard: 1989, 165).

“Because the entire universe is enclosed in curves; every universe is concentrated in a nucleus, a germ, a dynamized centre. And this centre is powerful, because it is an imagined centre (...) and this nucleizing nucleus is a world in itself. Miniature extends until the universe’s dimension. Once more, large is contained in the small” (Bachelard: 1989, 165). There is an intrinsic relationship between the infinitely small universe and the vastness; the poetic approach allows us to transpose the space in-between. Bachelard (1989:185) says “we are caught up in the perplexing dialectics of deep and large; of the infinitely small that deepens, or the large that extends with no limit.”

³⁶ André Pieyre de Mandiargues, poet and writer; he conceived the book *Métamorphoses (L’oeuf dans le paysage)*, from which Bachelard took this exemple.

When we reduce our vision, when we close our eyes, we are able to listen in a different way, we approach *matter* differently. The “ear knows that the eyes are closed, it knows that it is responsible for the being who is thinking and writing” (Bachelard: 1989, 186). Let us remember the poet René Daumal who teaches us another way to listen: “Yet listen well. Not my words, but to the tumult that rages in your body when you listen to yourself” (Daumal cit. by Bachelard: 1989, 186). The *intimate immensity* is formed in the *individual*, it is within ourselves, in “the movement of the motionless man” (Bachelard: 1989, 190). *The world deepens in the human being* and “when the dreamer really experiences the word *immense* (...) he is no longer a prisoner of his own being” (Bachelard: 1989, 200). Man is a vast being. Man’s “poetic faith is to be the mirror of immensity; or more exactly, immensity becomes conscious of itself through man” (Bachelard: 1989, 201).

The artist Paul Klee (2006) also shows us this awareness. Between man and the visible, there is the vision inversion: “I felt several times that it was not me, the one observing the forest. I felt, certain days, that the trees were looking at me, they were speaking with me... I was there, listening... I believe that the painter should be trespassed by the universe, not the opposite... I wait to be internally submerged, buried. I paint, maybe, to emerge myself.” (Klee cit. by Ponty: 2006, 29)

The sculptor Alberto Carneiro (2007) also reveals a profound relationship between the body and the landscape. In the work «Das Notas para um Diário e Outros Textos», he writes, “within me, landscape and nature are entities that may coincide as a circumstance that draws me out of myself, or as a will to (re)cognize myself inside me, in this fusion and metamorphose of being another within them” (Carneiro: 2007, 173). During the creative process, the individual “is able to engage in poetic creation working primarily with ideas (...) and this ideas may not always be defined by words, because the corresponding substances belong to the configurations of painting, sculpture, music and poetry. And it is not a coincidence that I refer to poetry, where we also work with words. But here, the word works differently, like the materials of painting, sculpture and music, like *poiesis*” (Carneiro: 2007, 179).

Poetic creation, as an artistic act, reveals itself in the “focal point of the things which are shared by the different arts (...) but it is also the infinite divergence point between all of them” (Sousa Dias: 2014, 58). Fernando Pessoa’s (2008) writings also reveal his poetic will: to feel everything in every possible manner, to feel the other’s veiled existence within us. Bachelard (1989) collects poems, poetic proses, literary documents that reveal the

freedom of imagination and he questions himself, “why should the actions of imagination not be as real as those of perception?” (Bachelard: 1989, 166).

Bachelard’s reflections about the nature of imagination are inclusive, in the sense that the dreamer, being immersed in his reverie, is no longer before a world that he classifies and normalizes, but a universe of possibilities, a welcoming world. The artistic act gives rise to all possibilities.

Poetry is “*poiesis*, it is a way of doing, because it is a way of saying what is not said, and it is not a different way of saying the given reality, but rather a way of doing or creating reality” (Sousa Dias: 2014, 34). The author adds, “in this point of view, poetry always says more than it spells, and it is this more, this object of saying what is not said, that poetry truly says” (Sousa Dias: 2014, 34). We return to the focal point between the different arts. Each art is a way of expressing this *unutterable*, “it is an excess of being within the being which expresses the unspeakable sensibility of being” (Sousa Dias: 2014, 35). The poetry principle is interpreted as a *sense articulation*, “a not only spoken articulation but a language that infinitely transcends the language” (Nancy: 2013, 6). Sousa Dias (2014:34) says, “it is certain that painting has always shared the poeticity (the silence of being), its ontological dimension, with poetry and with all arts.”

What is the meaning of this *silence of being* or *excess of being within the being*? What is the meaning of this *focal point* (but also *infinite divergence point*) between all arts? The artistic practice, “there lies the art enigma: to make the unknown fear – or, more precisely, the fear of the unknown – the secret source of inspiration: sounds and images, if I may say again, that haunt us. Art has not yet progressed beyond «the fear Age». But, it is precisely because of this, that art has something to teach to men who visibly don’t know what to do with fear (with the primordial fear) which dominates them and divides them into dominated and dominant” (Maia, et al: 2010, 36).

We start from vision, from the perception examination, to give rise to imagination (to the poetic creation) as a possibility to create reality and to bring us the world. Scientist and artist are unified in this *infinite convergence point of being human*. The *poietic* act is within the *individual*. The articulation between reason and imagination returns to the question about the openness of the human being to the world. “Because thinking is also changing position in relation to our own language. *We cannot always look at words in the same way*” (Tavares: 2013, 46).

In the work, *Os Passos em Volta*, Herberto Helder (2013) gives us an example that allows us to understand the importance of this articulation. The poet tells us the story of a painter who had an aquarium with a small red fish. Over time, the fish started becoming black, a blackness that was growing from the inside towards the outside. The black became darker; it was a black node growing from behind the red colour. The artist problem was that he wanted to be true to the referent and he didn't know what to do with the black colour that was growing in the fish. "Meditating on the reasons of this change (...) the painter assumed that the fish made the magic happen; because it showed that there is only one law which embraces both the world of material things and the world of imagination. It is the metamorphosis law. By understanding this kind of fidelity, the artist painted a yellow fish" (Helder: 2013, 21).

Gonçalo M. Tavares (2013) gives us an example of articulation based on two parallel lines. One of them is made by the metal instrument and the other one is made by particles of earth that are manually tossed in the air, in a movement made by man. These two parallel lines will meet, not in the infinite, but in the immediately following moment, the moment when the upper line breaks down into small particles and falls on the metal instrument.

All in all, this is a line that joins imagination and the euclidian and non-euclidian geometry: a line that breaks down into its own earth particles. The meeting point is its own transformation.

Metamorphosis

“Like countless others, the poet dreams behind the window. But he discovers a slight deformation in the glass, which will spread deformation throughout the universe.”³⁷

Gaston Bachelard, 1957

Questioning the intimacy of matter gives rise, as noted previously, to the creation of a debate between matter and shape. In this context, the *becoming* concept takes place through an organizational phenomenon or through an emerging and collective property within matter itself. Shape derives from the material action of matter over matter.

The problem's complexity increases with the differentiation between *inanimate matter* (*matter without life*) and *living matter*. Bachelard (1990:86) says “We can no longer expect to find life in the *elementary* since it works in solidarity with a complex organization. Is there a dominant characteristic of life as whole? (...) The plurality of life is so large that it implies including all the plurality of the vital processes. The biological problems cannot be explained, and cannot even be indicated by the conception of one vital fluid which distills matter, or animates matter.” When it comes to the living matter, life's activity is achieved through a *vital force* which determines its own shaping conditions. Life's basic principle takes place in its composition field, it has a (re)creating and self-constituent ability. Therefore, the principle of life is deeply *autopoietic*³⁸.

The inanimate matter *per se*, when compared with the life phenomenon, has no inherent ability to invert the entropy. Bachelard (1990:44) states that “A volcano is needed in order to prove that life's laboratory is still in activity within its own depths.”

However, life's exercise depends on the articulation (and a profound interaction) with the inanimate matter. “Life's phenomena (...) reintroduced the chemical phenomena in a materially asleep planet, within a chemically inert planet. The plant is an alembic, the

³⁷ BACHELARD, Gaston, *A Poética do Espaço*, Martins Fontes, São Paulo, Brasil, 1989, p.165.

³⁸ The term *autopoiesis* was developed by the Chilean philosophers and biologists Francisco Varela and Humberto Maturana. This concept is related to the inherent ability of creation and autonomous self-constituent characteristic of all living systems.

stomach is a digester. It seems that due to the living beings, nature rehearses itself for facticity” (Bachelard: 1990, 44) Due to life’s own complexity, the rational being was created, and with him, the cultural condition was born. Human’s rationalist action gives rise to the science of matter transformation. The relationships between (living or inanimate) matter are dynamized by man himself.

In this context, we introduce two scientific investigations (two ways of approaching the concept of *matter*) which were developed throughout this work.

The first scientific investigation (Red copper glass by spray pyrolysis³⁹) articulates the inanimate matter transformation by heat. The debate is about the formation of a specific colour in conformity with a construction model.

It should also be noted that the actual colour attribute is even more complex because it is the result of the articulation between the matter of the world and our vision. The colour concept depends profoundly on the phenomenon perception. Recalling again the words of Bachelard (1990:235), “Without doubt, let’s propose a new philosophical stage: *the constructed colour*. And before this notion analysis, the philosopher may say that it will always be a useless deviation because we always need to return to the philosophical problems of perception (...) but our debate (...) is to monitor the displacement of the substantiality quality.” In the context of a scientific investigation, “the chemist approaches the colour based on a creation model” (Bachelard: 1990, 235).

The scientist’s rationalism is clear. Let’s see an example related of our investigation: the scientist intends to create a red colour in the glass substrates. The colour is rationally structured before starting the experimental procedure. Bachelard (1990) tells us about the ability to create a *written colour*. The reactants are chosen according to the reaction products that we want to obtain.⁴⁰ The main reactant (copper acetate is laid down on the glass surface (by spray pyrolysis⁴¹) and the reaction exists due to the heat (and a temperature which is difficult to define⁴²). The colour (red copper) only appears after the pyrolysis. In this process, the copper ions Cu^{2+} are reduced⁴³, or in other words, they are

³⁹ The scientific investigation report is presented in the dissertation annex.

⁴⁰ One possible chemical reaction that may have occurred during the pyrolysis is represented below:

$\text{Cu}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{CuO} + 2(\text{CH}_3\text{COOH}) + \text{H}_2\text{O}$

⁴¹ The pyrolysis concept is etymologically derived from the greek language (pyrós: fire + lysis: dissolution) and it consists of a reaction which occurs due to the action of temperature.

⁴² In this case, the temperature definition (450°C) was only achieved after many iterations.

⁴³ The scientist conceives the reduction reaction through the formula: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \Rightarrow \text{Cu}(\text{s})$. The copper ion receives two electrons (the element changes into its natural oxidation state, which is the oxidation state 0).

transformed into nanoparticles⁴⁴ Cu. However, *when a reduction occurs, an oxidation takes place*⁴⁵. The energy transits from one matter to another. In fact, the energy changes matter.

Light is energy (composed of photons – corpuscles or elementary particles) that propagates (as electromagnetic waves) in the visible spectrum (TILLEY 2000). Therefore, light is an energy source, it changes the matter and it is also due to light that we are able to discern the visible. But it is also because of its absence that we are able to discern the invisible. Besides, it is known that this is only a qualification in relation to the human eye.

The ontological classical way to enunciate copper colour would be: *copper is reddish-orange*. However, copper ions change colour accordingly with several factors, such as their oxidation state. The copper ions Cu have a typical vibration (in other words, typical wavelengths and vibration frequencies) which correspond to a specific colour. Ruby copper glass absorption spectrum has an absorption peak at approximately 560nm (Navarro: 1991). The human eye perceives this vibration frequency as a red colour. In the case of coloured glass with Cu²⁺ ions, the perceived colour is turquoise blue; this colour has an intense absorption peak between 780nm and 810 nm (Navarro: 1991). In this context, “a subtly studied *substance* reveals itself as an *ex-stance*. The properties of a substance are interconnected with the external conditioning experience. The unique has no properties” (Bachelard: 1990, 230) This brings us back to the *becoming* concept as an inherent property of matter.

Therefore, the issue is the true colour attribute. Bachelard (1990:231) says, “For many centuries now, it is known that the gold material rejects its own colour. If we illuminate it with a white light⁴⁶ it absorbs all the other colours and emits the yellow. If we illuminate it with a light deprived of yellow colour, it cannot be yellow.” In the same way, the red copper colour that we perceive in the glass samples corresponds to a vibration frequency which is ‘rejected’ by the matter itself and is then perceived by the human eye. “Therefore, colour is not a true *attribute* of the substance. It is an activity – or rather reactivity –

⁴⁴The nanoparticles that constitute red ruby copper glass are made of colloidal aggregates with a diameter range that varies between 20 and 50 nanometres. The aggregates dimensions depend on several factors, such as the colouring agent concentration and the temperature reaction. If the colloidal aggregates increase, there is an absorption band displacement towards larger wavelengths (the colour becomes brownish). If the temperature increases too much, there is an ionic dissolution in the glass bulk and the red colour is no longer perceived. (Navarro: 1991).

⁴⁵The reaction only occurs in the glass surface with Tin. There are several studies regarding the importance of Tin as an important copper reduction agent: “In order to obtain a good copper ruby in industrial production the presence of tin is essential. Glasses melted without tin might turn blue due to the presence of Cu²⁺ ions, or yellow or yellowish brown and not strike during heat treatment” (Bring: 2006, 14).

⁴⁶The white light is the combination of lights (with different wavelengths) in the visible spectrum.

expressed under certain conditions” (Bachelard: 1990, 232). Colour is the result of a construction, “it is in fact, a structure. And this structure is followed, piece by piece by the chemist” (Bachelard: 1990, 235).

In the case of the thin films, the layer thickness definition is also essential in order to determine the colour⁴⁷. The colour of the matter is also related to its own extension. In this context, let’s take the example of the gold material which has several colours according to the layer thickness: “the thin layers have no well-defined colour, unless you give them a regular thickness, a well-defined thickness. Here is a colour scheme related with the layer thickness: «gold is green-yellow above 4µm; it becomes green-blue and then clearly green at 2,7µm; it is finally violet-rose at about 1,5µm” (Bachelard: 1990, 229). The thin film layers are difficult to produce, in other words, the specific colour definition depends on the “combination between the thinning techniques (...) with the meticulous definition of the matter thickness.” (Bachelard: 1990, 229) In the case of spray pyrolysis⁴⁸, the thin film suffers a ‘metamorphose’ by the action of temperature (and the metallic oxide nanoparticles are incorporated in the glass).

Also in the context of the scientific investigation, we would like to include another example related to the matter experience conditioning. Let us make an inverted exercise. For instance, we observe a red glass sample but we don’t know the origins of the specific colour that we perceive. However, the scientist knows that coloured glass absorption spectra have specific absorption bands and typical wavelengths. So there is the possibility to observe the measured data from which the scientist rationalizes the readings and determines both colour and colouring methods (for example, it is possible to understand if the colour derives from nanoparticles in the glass surface or, in contrast, if it derives from the ionic dissolution into glass). It is another way of looking at and perceiving matter, from which we can rationally predict the colour. *It is about inferring the matter presence from its own action tracks.*

⁴⁷ In context of the Master of Glass Art & Science (FCT,UNL & FBA,UL), the artist Marta Maranha developed several scientific experiments related to glass thin films. In this case, it was extremely difficult to define the thin film’s thickness and this difficulty was expressed into several colours and transparencies in the glass surface: “Copper mirrors are usually pink when the thin films are opaque, they are yellow-greenish when translucent and they are blue when the thin films have an extremely thin thickness. This copper colour change may happen during deposition (...) when heated the mirrored thin layers acquire a rose-salmon colour due to nanoparticles formation.” (MARANHA 2013, 33) The different colours and transparencies are visible in several images (pgs. 8, 40, 41) of the above mentioned dissertation.

⁴⁸ The layers thickness definition and their specific morphology and structure depend on various factors such as the reagents, their concentration, the temperature and the dimensions of pulverized particles into the samples. (Enescu, et al, 2008) .

We shall continue Bachelard's (1990:238) line of thought, "holding a pen in his hand and before a blank sheet of paper, the chemist dreamt of working out formulas (...) which would build a specific colour." In essence, colour conceives many ways of rationality.

The second scientific investigation (*Contemporary glass biodeterioration by fungi*⁴⁹) approaches the relationship between living matter and inanimate matter. In this case, the scientist does not first conceive of a chemical reaction formula. On the other hand, the scientific work is based in the observation of life itself and its (re)creation movement.

The scientist selects two fungi specimens;⁵⁰ he places them over the glass substrates and observes the fungi growth. After a specific time lapse, all the samples are collected for observation. The scientist observes first all the glass surfaces 'impregnated' with life and then removes the ecosystem from the glass surface. The methodology is detailed taking into account an attested scientific support, *umpteenth times attested* in the scientific community.

The observations also follow many ways of rationality. Just as in the previous investigation, the exercise is based in the articulation between the observation of samples and the data interpretation.

The optical microscope allows us to access scales that approach the infinitely small universe. The observations are made in orders of magnitude that go into the micrometre (one thousand times smaller than the millimetre). The scientist observes the mycelium growth and the creation of corrosion patterns in the glass surface (for example, hyphae fingerprints and crystal formation). The large is once again contained in the small "in the infinitely small that deepens" (Bachelard: 1989, 185).

The scientist also uses other techniques which allow him to access elements and molecules as a complement to the samples observation. As in the previous investigation, it is also possible to do an inverted exercise.

The molecular connections have typical vibrations. μ -RAMAN⁵¹ spectroscopy allows us to access the specific minerals or crystals which are formed on the glass surface due to the

⁴⁹ The scientific investigation report is presented in the dissertation annex.

⁵⁰ The selected specimens were *Aspergillus* sp. and *Penicillium* sp.

⁵¹ "The main spectroscopies employed to detect vibrations in molecules are based on the processes of infrared absorption and Raman scattering (...) Raman spectroscopy uses a single frequency of radiation to irradiate the sample and it is the radiation scattered from the molecule, one vibrational unit of energy different from the incident beam, which is detected (...) In Raman scattering, the light interacts with the molecule and distorts (polarizes) the cloud of electrons round the nuclei to form a short-lived state called a 'virtual state' (...) The energy changes we detect in vibrational spectroscopy are those required to cause nuclear motion" (Smith: 2005, 3).

presence of fungi (due to the interaction between the living and inanimate matter). SEM-EDS⁵² is another technique which allows us to observe the sample's surface and also to identify the elements (atoms) that compose them. The spectra analysis allows us to identify the typical vibrations of a specific matter. There are several ways of understanding the phenomenon from the rationalization of the data. *Once again, it's about inferring the matter presence from its own action tracks.*

Matter organizes itself due to energy transactions. In this context, Bachelard (1990:208) proposes a "real existentialism of energy." The relationship between *being* and *having* deconstructs, in other words, the energy absolutely *is*. It is a reconversion exercise where we say twice the same thing: "the being is energy – and the energy is the being. Matter is energy (...) in the same instant, the 'having' kingdom is deeply transformed (...) energy is the basis of everything" (Bachelard: 1990, 208).

When we say *the being has energy* or *matter has energy*, we are actually limiting the concept because the energetic principle is within the phenomenon. The author adds "the phenomenon (...) is the energy manifestation (...) the chemical reactions are energy relations (...) and it is due to energy laws that we can explain the matter phenomena" (Bachelard: 1990, 209).

In the course of the scientific investigations, the artist deepens his knowledge and develops a reflection: *The energy, the relationships within energy, these are the basis of everything. Just as in the chemistry of inanimate matter, the chemistry of life is also a permanent construction and deconstruction project.* But there is in fact a fundamental difference between the chemistry of inanimate matter and the chemistry of life; it is a difference that takes place in that part of the world beyond the control of scientific observation. In a double vision, both scientist and artist give rise to *wonder*.

The artist collects objects that don't represent the final samples or the scientific results but their *negative (the scientist action tracks)*.

The glassmaker table top bench also reveals a code related to the arrangement of the glassblowing tools, it shows the effects of fire on the wood surface. "Let us recall the hasidic saying «if you want to find fire, you shall look for it in the ashes», this teaches us to

⁵² "SEM-EDS technique (scanning electron microscopy – energy dispersive spectrometer) allows us to analyse the surfaces and transversal sections at the morphological level. It also allows us to obtain information regarding the change of the elements composition" (Rodrigues: 2012, 10).

recognize the fire as an essential force which we cannot perceive unless through its effects.” (Molder: 2011, 68).

The gesture repetition, the movement multiplication until the filling of the space (a space that adjusts to the human body scale), the rhythm of the action gives rise to the work of art. Bachelard’s (1980:20) metaphysics of time gives us a clue for this artistic doing: “In order to think, to feel or to live, it is necessary to carry out our actions in an orderly manner, agglomerating instants in rhythm fidelity and uniting reasons in order to create a vital condition.”

The breathing dynamics evolves into *a sense of carving the air with our own body*. Our way of life is translated into a natural movement of inspiration and expiration, of gesture repetition. In this regard, the artistic doing evolves on the basis of this action (respiration) as a principle. The glassblower breath is an exercise of expiration which gives shape to the vitreous material. Similarly, the being exhales into the air or into other materials where all the blowing matter condensates and transforms into small droplets. The artist’s search for the material intimacy leads him to find the most intimate sculpture gesture, *to sculpt from the inside to the outside*, from his own body’s matter.

Therefore, in the same way as *matter gets out of the shape imprisonment*, sculpting cannot be limited to the actions of addition or subtraction. The space deconstruction (inherent to the act of sculpting) has a possible translation from our own breathing. “The laboured matter, the labouring matter, all the matter in their own mixing actions, these are all lessons of intimacy” (Bachelard: 1990, 26).

Following Nietzsche’s line of thought, we also reveal that one is an artist “on the condition that one feels as content as ‘the thing itself’, what non artists call the ‘form’. This fact means that one belongs to an overturned world; because now all content appears to us as purely formal, including our own lives” (Nietzsche cit. by Miranda: 2012, 67).

The deepening of the matter concept is only possible through a *double vision* which surpasses the scission that occurs with the concept rationalization. “The analytical and intellectual procedure (...) is replaced by the enlivening of the poet, which recaptures the intrinsic harmony man/nature” (Veiga Simão: 2010, 60).

Furthermore, there is also the question about the specular image, about the ‘double face’ which mirrors the landscape. The stainless steel surface is polished towards the relationship with the other, where the visible is unveiled through other places. The difference between

the specular faces and the other surfaces is based on a continuous action on the matter, towards a deeply small granulometry. It is through one's own action that a double space is born. It is about the immersion on the boundary by its own dissolution; it's about deepening one's body through one's own extension.

The body is no longer a *specular image*, but an expansion in which the existence takes place⁵³. Therefore, the issue is not about the reflective side, but the back side of the mirror. In this context, Vilém Flusser (2012:78) gives us an example related to the glass mirrors “the silver nitrate is completely opaque. When I contemplate it, I don't see much. In fact, I don't see anything. Why am I so interested in this boring nothingness that I see? Because I know that it is responsible for the reflections that happen in the other side (...) the new art proves it. They travel all the roads in the region which extends from the other side of the mirror (...) Today a new age begins, the age of the reversed mirrors.” However, “nothing happens on any side of the mirror, but in the relationship between both (...) in the space that joins them, in the thin dividing line (...) an infinitely thin line that unites and separates both matter and simulacrum” (Miranda: 2012, 78).

Concerning the specular image, Bachelard (2009:198) puts forth the idea that “through the pure lake mirror, the sky becomes aerial water. Therefore, the sky is for the water, a communion within the verticality of the being. The water that reflects the sky is the depth of the sky. This double space mobilizes all the values within the cosmic reverie. If the being that dreams without limit, if the dreamer that is open to all the other dreams lives intensely in one of the two spaces, he still wants to live in the other space.”

And it is from the intimacy of matter (from matter's own forming ability) that man has the potential to overcome a fragmentation which occurs due to layers and layers of image scraps which deposit in reality. Memory somehow became ill but the human being is unique in his multiple abilities of adjustment.

Italo Calvino (2006:112) raises the following question in his conference about the «visibility» concept: “Is it still possible to evoke images *in absentia* within a world increasingly submerged by prefabricated images?” The author's search for an answer takes place in his own literary work. The strategy adopted is based in a change of scale factors. It

⁵³ Merleau-Ponty (2006:21) says “The enigma consists in the fact that my body is at the same time the seer and the visible. He, the one who sees all things can also look at himself, and then recognize «the other side» of his seer power in what he actually sees. He sees while looking at himself, he touches while touching himself; he is visible and sensitive to himself.”

is about a vision that covers the world from the cosmology to the intimacy, from the infinitely large world to the diving into the land.

In Calvino's book «Palomar»⁵⁴, the astronomical observatory reverses the vision towards the planet earth and one is able to walk the extreme distance between the panoramic vision and all the details, like an exercise on the infinite possibilities of seeing. One registers the world while in between the multitude and the distinct individuality; one's able to see "the shapes how the human sand aggregates and how they tend to a certain order related to movement lines, drawings that combine both regularity and fluidity, like the rectilinear and circular lines of a rake... And one perceives a possible harmony somewhere between the sand/humanity and the rocky world, like two non-homogeneous harmonies: the non-human one, in a balance of forces which does not seem to correspond to a certain purpose; and the human one, which aspires to an indefinite rationality of geometrical or musical composition" (Calvino: 2009, 102).

The human being approaches reality, he starts from a panoramic vision on the world and then descends until the smallest, in an encounter with the intimacy of matter and our own existence, "in a situation whose improbability one is painfully fully aware (...) If the sea wave is full of sewage we need to include them both, because our materials are at the same time matter and shape both twisted and mixed" (Miranda: 2012, 55).

To reflect and to think about the instances of the matter is to permanently rearticulate the concept, with no theoretical or aesthetic guarantees.

In effect, says Ponty (2004:68), "the modern thinking offers us a double nature of incompleteness and ambiguity (...) we conceive all the science works as temporary and inexact." There are multiple possibilities of articulation which are revealed from our own vision or from the perception abilities, but also from what we do not see and infer (from the negative of the actions). The human beings run across the universe through the dialectics of reason and imagination. Bachelard (1989:155) tells us "To climb the latter of the word is to, step by step abstract. To go down to the cellar is to dream (...) To go up into really high places, to descend down to the depths are both allowed to the poet which unites terrestrial and aerial."

The poet does not need to locate himself in such an "almost divine angle of vision. All he needs is to accept his intrinsic human condition: the man is *nothingness into being* (...) And

⁵⁴ The name of the book «Palomar» is the name of an Italian astronomical observatory.

given that he does not write from nothing but from his precarious self (...) this poet will need to subscribe, even fervently, his vital contingency – his *into being* – as well as recognize, after all, his homeland or original substance – the nothingness – from which he mysteriously emerged” (Jiménez: 1987,15).

The humanizing potential of art, of all the poiesis, is to makes us aware of the articulation movements (the constituent relationship) between the individual and the world. Therefore, the dwelling sense can always be reversed. Let us remember: the chemistry of life results from the articulation (a profound interaction with the inanimate matter). This relationship results in a composition, a combination of articulations between the individual and the world. The sculptor breathes in the diaphanous matter; afterwards he exhales a formative shape which dissipates into the landscape. Respiration exercises, inspiration and exhalation. Coexistence, dissolution and connection. Articulation, interconnection. Autopoietic impetus.

Art thus instead of giving up, insists. It translates into a force which does not abandon the world, helping us to see. Therefore, the forms ‘dilute’ all the historical rigidity; they are able to translate themselves as content into action; the forms are matter-becoming, they emphasize the profound, one might say the subliminal, which is so hard to discover through reason. Therefore, form releases itself from its “old structure which opposes it to its own content or matter” (Miranda: 2012, 67). The form is formative, it is an articulation instead of an opposition.

Therefore, the dialectics of reason and imagination allows us to return to the thinking about the universal human condition.

In conclusion, the poet’s chant, the artist’s chant, the scientist doing, is nothing more than the intense voice of the world’s explorer, a world which surpasses us in all circumstances. However this world is born and flourishes from the *inside-to the outside-to the inside*.

“Perhaps, we may still call INDIVIDUAL to the denser zone within the nebulous ensemble of processes, which have their own properties and intensities, which converge to a certain body, and finally say, I am a cloud, once again I lost my identity card.”⁵⁵

Maria Ampá, 2011

⁵⁵ AMPÁ, Maria, *Maria Ampá*, Edição Mosca Bradu, Guiné Bissau, 2015

CONCLUSION

Between reason and imagination, the individual searches for matter. The deepening of scientific concepts gives rise to the possibility of approach within the intimacy of matter which calls into question one's own artistic process.

Matter becomes shape. Matter is self-constituent; it adds itself into the incompleteness of knowledge. The shape is matter-becoming, it is content into action. Therefore, the shape is also self-constituent, it is an articulation with the other, no longer an opposition. The intimacy of matter increases as we develop an understanding about the relationship between energy and matter. Matter is energy's own expression. Just as space-time is the coordinate system in general relativity, the being results from an inseparable articulation between matter and energy. One might say, matter-energy absolutely *is*.

The concept's complexity deepens in a double sense which runs across the cosmological universe and the infinitely small world. The limits are explored through the line trails, through the action tracks. The presence of matter is accentuated as science evolves. It is about an action that doubts itself, it is about a truth which is based in the multiple possibilities of seeing and does not exclude fissures.

Matter inhabits the individual and the mystery of life lies between the living and the inanimate matter. It lies in the fact that life is able to transmit, generation after generation, all the genetic knowledge impregnated in its own matter. However, it is still not possible to create life my molecules synthetized in the laboratory. The question now arises: How does life create life? How to express this unutterable?

The poietic act allows us to give visibility to the unutterable⁵⁶. Between man and matter, there is a possibility to reverse the dwelling sense. The artistic process gives rise to the imagination and there is the construction of a freedom space where the individual inhabits the matter.

⁵⁶ Tomás Maia tells us about an unutterable that becomes visible: "The image is not the visible without the word, but the inability to say (to nominate) that becomes visible" (Maia: 2009, 179).

Therefore, it is no longer about the mobilization of a relative truth (generated by different points of view dependant on the observer and the observed) or the deconstruction of a space-time.

Just as matter-energy defines itself as becoming, the visible is created from our own body, from its abilities of creation and from its relationship with the other.

Note: Portuguese to English translation by Margarida Alves